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## THE SEVEN WORLD-PROBLEMS.

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WHEN, eight years ago, I undertook to address a public sitting of the Association of German Naturalists and Physicians, I hesitated for a long time before deciding to choose the "Limits of our Knowledge of Nature"† as my subject. The impossibility, on the one hand, of comprehending the existence of matter and force, and, on the other hand, of explaining consciousness, even in its lowest degree, on a mechanical theory, seemed to me a truism. That even the simplest sensation can not be made comprehensible as the result of any arrangement or movement of matter, has long been recognized by eminent thinkers. Although I knew that false ideas on the last point had been widely diffused, I was almost ashamed to offer so stale a draught, and hoped to awaken interest only through the novelty of my arguments. The reception given my exposition showed me that I had mistaken the condition of the case. Treated coolly at first, my essay soon became the object of numerous criticisms, which seemed to come from a diversity of points of view—from cordial approbation to utter rejection and censure—and the word *ignorabimus*, in which the investigation culminated, became a kind of philosophical shibboleth.

Flattering as it was to me to see my exposition regarded as a Kantian fact, I must decline the honor, for nothing was contained in it of which any one might not have informed himself by a study of the older philosophical writers. But, since philosophy was perverted by Kant, its culture has taken on so esoteric a character; it has, so far, unlearned the language of common sense and intelligent thought, and

* An address delivered in the Academy of Sciences at Berlin, in honor of the birthday of Leibnitz, July 8, 1880.

† See "Popular Science Monthly," vol. v, p. 17 (May, 1874).

evaded the questions that move unprejudiced youth most deeply, or treated them from a superior altitude as officious speculations; and has, finally, held so hostile an attitude toward the new world-power, natural science, that it is not surprising that even the recollection of the earlier achievements of philosophy should have been lost. This is, indeed, partly due to the circumstance that the newer philosophy stands in a negative or in no clear relation to positive religion, and avoids expressing itself on certain questions; so that it has happened that the most pregnant problems in metaphysics have not been set forth and discussed by philosophy, at least not in a language acceptable to scientific men, since the middle of the last century. This may be one of the reasons why philosophy is often despised as objectless and useless, and why, when natural science and philosophy touch at so many points, such ignorance and lack of preliminary ideas are shown in connection with actual achievements.

I was reproached, on the other side, because I had assigned impassable boundaries to the human powers of knowledge, by men who could not understand why consciousness could not be made comprehensible in the same way as the development of heat by chemical action, or the excitement of electricity in the galvanic circuit. Cobblers left their lasts and sneered at the humble confession of "Ignorabimus," by which "not-knowledge" was declared in permanency; and I was denounced as belonging to the Black Band by fanatics who should have known better, and who showed anew how nearly together despotism and extreme radicalism dwell. More temperate heads betrayed the weakness of their dialectics in that they could not grasp the difference between the view which I opposed, that consciousness can be explained upon a mechanical basis, and the view which I did not question, but supported with new arguments, that consciousness is bound to material antecedents.

David Friedrich Strauss, who had recently turned from theological studies to natural science, saw more sharply. It did not escape him that I had put myself in regard to mental processes at the point of view of the inductive philosopher, who does not separate the process from the substratum on which he learned to know the process, and who does not without sufficient motive think of the process as disconnected from the substratum.

Even he criticised in a remarkable way my declaration of the incomprehensibility of consciousness on a mechanical basis, saying: "There are confessedly three points in the ascending development of nature to which the appearance of the incomprehensible is especially attached. They are the three questions, How has the living arisen out of the lifeless, how the sensible out of the senseless, how the understanding out of the not-understanding? The author of the 'Limits of our Knowledge of Nature' holds the first of the three problems, A, to be solvable. He facilitates the solution of the third problem, C, that of

intelligence and free-will, apparently by including it in the closest connection with the second, that of reason, as the highest degree of the consciousness already given, with sensation. The second problem, B, that of sensation, on the other hand, he holds to be unsolvable. I grant that one might more readily enlighten me, if he should say to me: 'A, that is life, is and must remain inexplainable; but that once given, sensation and thought follow of themselves—that is, by natural development'; or, if it were stated in the inverse sense, 'A and B may indeed be comprehended, but the understanding is strained at C, or self-consciousness.' Either of these views appears to me more acceptable than the one that the middle station only is impassable."

Strauss has not touched the marrow of my observation. I called astronomical knowledge of a material system such knowledge as we might have of the planetary system, if all the observations were accurate and all the difficulties of the theory overcome. If we had astronomical knowledge of what is going on in ever so obscure an organ of the animal or vegetable body, our demand for a causal agency would be as well satisfied, so far as the nature of our intellect permits with reference to that organ, as with reference to the planetary system; but, if we had astronomical knowledge of what occurs within the brain, we would still not be advanced a hair's breadth with reference to the origin of consciousness. In regard to these problems, Laplace and Leibnitz, whose minds were so immeasurably superior, yet similar to ours, were no wiser than we; and if Leibnitz had realized his fiction that he could compose a *homunculus*, atom by atom, molecule by molecule, he might, perhaps, make his creature think, but not comprehend how it thought.

The primary origin of life in itself has nothing to do with consciousness, but is a question only of the arrangement of atoms and molecules and of the production of certain movements. Consequently, not only is astronomical knowledge thinkable of what we call original production, spontaneous or equivocal generation, or heterogeny, but it would satisfy our demand for a causal agency for the primary origin of life as well as in regard to the motions of the heavenly bodies. This is why, speaking with Strauss, "in the ascending development of nature" the gap in our apprehension does not open at the point A, but at B. I have not maintained that, sensation being given, every higher stage of mental development becomes comprehensible; that problem C is made solvable without further steps. I attached weight to the incomprehensibility of the simplest sensations on mechanical grounds, only because the incomprehensibility of all the higher mental processes follows from it by an *a fortiori* argument.

The origin of life seems to have become veiled in a deeper obscurity since men have hoped with the aid of the microscope to see the living come from the dead in their laboratories. According to M. Pasteur's researches, heterogeny is underlaid by panspermy, and, where life was

believed to originate, it has only been developed from germs that were already present. Yet those who will not adhere to a wholly childish view may be logically compelled to concede a mechanical origin of life. Hardly any one can now be found to advocate the doctrine of periods of creation by which the Almighty was supposed to have repeatedly destroyed his work to do it over again for better or worse, in the face of geological facts and the theory of descent. The believer in a final cause must admit that such a proceeding is little worthy of a creative Almighty. It is most highly becoming to him once by supernatural interference with the world's mechanism to call the simplest germ of life into being, and let further organic creation proceed from that. If this is conceded, it is permissible to ask if it is not still more worthy of the creative Almighty to avoid even that single intervention by means of established laws, and to endow matter from the beginning with the power of originating life under suitable conditions. There is no reason for denying this view, but with its acceptance the possibility of a mechanical origin of life is conceded, and we have only to consider whether the matter which can thus mechanically compose itself into a living condition always existed, or whether, as Leibnitz thought, it was created by God.

I conclude that astronomical knowledge of the brain would not make consciousness more comprehensible on a mechanical basis because it must be indifferent to a number of atoms of carbon, hydrogen, oxygen, nitrogen, etc., how they are situated or how they move, unless they already had individual consciousness ; and this would not help to explain consciousness in general, or the aggregated consciousness of the brain.

I hold this conclusion to be fully convincing. Herr Haeckel, however, has advanced as a metaphysical axiom that every atom possesses an inherent quantity of force, and is in this sense "be-souled," and that without the acceptance of an "atom-soul" the commonest and most general phenomena of chemistry are inexplainable. "Pleasure and displeasure," he says, "desire and aversion, attraction and repulsion, must be common to all the atoms, for the movements of atoms that take place in the formation and decomposition of all chemical compounds are susceptible of explanation only if we ascribe feeling and will to them. . . . If the 'will' of man and the higher animals seems to be free in contrast with the 'fixed' will of the atoms, that is a delusion provoked by the contrast between the extremely complicated voluntary movements of the former and the extremely simple voluntary movements of the latter." Quite in the spirit of the false philosophy from the same source that has been so pernicious to German science, Herr Haeckel goes on with the construction upon "unconscious recollection" of a certain "vivified" atom-complex that he calls "plastidule."

Thus does he disdain the path of inductive research shown us by

La Mettrie, and sin against one of the first rules of philosophizing—"*Entia non creanda sunt sine necessitate*"; for what purpose does consciousness serve, what mechanism? And if the atoms feel, what need of organs of sense? He furthermore overlooks the difficulty that I have fully pointed out, of comprehending how the numerous "atom-souls" can give rise to the aggregated consciousness of the whole brain.

A more accomplished morphologist might be excused for not being able to distinguish the ideas of will and force, for misconceptions similar to this have been shown even by better-schooled men. Philosophers and physicists have attempted to explain the distant action of bodies upon each other through presumably empty space by means of a will dwelling within the atoms. A wonderful will, indeed, that must always belong to two!—that must will whether it wills or not, and that in the direct ratio of the product of the masses, and the inverse ratio of the square of the distance!—a will, the projected subject of which must move in a conic section—a will that reminds us of the faith that can move mountains, but which has never been taken account of in mechanics as a cause of motion.

At all events, the opposition that has been offered to my assertion of the incomprehensibility of consciousness on a mechanical theory, shows how mistaken is the idea of the later philosophy that that incomprehensibility is self-evident. It appears, rather, that all philosophizing upon the mind must begin with the statement of this point, and thus with one of my corresponding arguments; if mechanical consciousness were comprehensible, there would be, in the strict sense, no metaphysics.

A more recent effort to enlarge the barriers of knowledge and throw light upon the nature of matter proceeds from the Scottish mathematico-physical school, from Sir William Thomson and that Mr. Tait whose chauvinism renewed the dispute over Leibnitz's part in the discovery of the infinitesimal calculus, and who went so far as to call Leibnitz a thief, and to whom, therefore, the honor of being named in this hall does not properly belong. Sir William Thomson and Mr. Tait believe that certain important peculiarities that we must ascribe to atoms may be derived from the remarkable properties which Herr Helmholtz has discovered in the vortices of fluids. While it would be rash lightly to reject this theory because it may fall short on some points, it can be safely asserted that it is as little competent as any of the previous theories to reconcile the contradictions which our understanding encounters in its efforts to comprehend matter and force. It, moreover, acknowledges the second of the difficulties that oppose our conception of the world, by granting that the vortex-movement either has existed from eternity or has arisen through a supernatural impulse.

We may count and distinguish seven of these difficulties, of which I call those transcendental which appear insurmountable when we

come to meet them in considering the ascending development of nature.

The first difficulty is the existence of matter and force, and is in itself transcendental.

The second difficulty is the origin of motion. We see motion arise and cease; we can conceive matter at rest, and motion appears to be something casual to it. It does not satisfy our demand for a causal agency to think of matter evenly distributed in illimitable space and at rest for endless time. Unless we admit a supernatural impulse, a sufficient occasion for the first motion is lacking. Or, if we imagine matter as in motion from eternity, we give up the elucidation of the point. I regard the difficulty as transcendent.

The third difficulty is the origin of life. As I have often said, I see no ground for considering this difficulty transcendent. When matter has once begun to move, worlds may originate; under suitable conditions, which we can as little imitate as we can those under which a multitude of inorganic processes take place, the peculiar condition of the dynamic balance of matter which we call life may also be produced. If we admit a supernatural act, one such act, creating the animated matter, is enough.

The fourth difficulty is offered by the apparently teleological arrangement of nature. Organic laws of formation can not work adaptively unless matter was created with adaptive purpose in the beginning; and they are inconsistent with the mechanical view of nature. This difficulty is, however, not absolutely transcendent, for Mr. Darwin has pointed out in his doctrine of natural selection a possible way of overcoming it, and of explaining the inner suitableness of organic creation to its purposes and its adaptation to inorganic conditions through a concatenation of circumstances operating by a kind of mechanism in connection with natural necessity.

I have already, on a similar occasion to the present, considered in this place the degree of probability that belongs to the theory of selection. "We might always," I said, "while we hold to this theory, have the feeling of the otherwise helpless sinking man, who is cleaving to a plank that just bears him up even with the surface of the water. In the choice between the plank and destruction, the advantage is decidedly on the side of the plank." The fact that I compared the theory of selection to a plank on which a shipwrecked man seeks deliverance excited so much delight in the camp of the other side that they, in the pleasure of repeating it, made a straw of the plank. There is, however, a great difference between a plank and a straw. The man who is dependent on a straw sinks; a common plank has saved many a man's life. Thus the fourth difficulty is no longer transcendent when it is earnestly, thoughtfully met.

The fifth difficulty is the origin of simple sensations, and is quite transcendent.

Recollecting how I have showed the hyper-mechanical nature of this problem, and consequently its transcendence, it may be profitable to consider how Leibnitz does this. He makes the bare assertion in many places in his writings that consciousness can not arise through any forms and movements, or, as we would now say, through any arrangements and movements of matter. In his "Nouveaux Essais sur l'Entendement Humain," he lets his advocate of sensualism, Philalethes, say, almost in the words of Locke, whose views the work otherwise opposes: "It may be proper to lay more stress on the question whether a thinking being can proceed from an unthinking one without sensation and consciousness, like matter. It is tolerably clear that a material particle can never bring about anything by itself, or impart motion of itself to itself. Its motion must either have existed from eternity, or have been imparted to it by a superior being. But, even if it were from eternity, it could not beget consciousness. Divide matter as if in order to animate it, into as small particles as you will; give them whatever figures and motions you will; make them into balls, cubes, or cylinders, whose dimensions shall reach only a thousand-millionth part of a philosophical foot. However small the particle may be, it will produce on other particles of the same order no different influence from that which bodies an inch or a foot in diameter exercise upon each other. We have the same right to expect to produce sensation, thought, consciousness, by the combination of gross particles of matter of the right shape and mode of motion, as by means of the most minute particles. The latter meet, jostle, and resist each other just as the coarser particles do, and they can do no more. But if matter could immediately and without instrumentality, or the help of forms and movements, create of itself out of itself sensation, perception, and consciousness, that would have to be an inseparable attribute of matter in all its parts." Theophilus, representing the Leibnitzian idealism, approves this conclusion as well founded and just, and says that he is of the opinion of its originator, that "there is no combination or modification of the particles of matter, however small they may be, that can beget perception; for, as can be clearly seen, the gross parts can not do it, and all the processes in the small parts are proportional to those in the gross ones." In his "Monadology," Leibnitz says more briefly: "We are constrained to confess that perception and whatever depends upon it are inexplainable upon mechanical principles; that is, by reference to forms and movements. If we could imagine a machine, the operation of which would manufacture thoughts, feelings, and perceptions, and could think of it as enlarged in all its proportions, so that we could go into it as into a mill, even then we would find in it nothing but particles jostling each other, and never anything by which perception could be explained." Thus, Leibnitz has reached the same conclusion as we. Yet we may remark on this point, first, that Locke's demonstration as accepted by Leibnitz has lost its validity through the prog-

ress of science; for, according to our present views, we do at least come to a point where matter displays new properties under excessively fine division, as in the cases of diffusions, chemical processes, crystallization, and in organisms. It is remarkable that it never occurred to Leibnitz or Locke that it is by no means all the same whether charcoal, sulphur, and saltpeter lying together are in large lumps or ground down in definite proportions to the fineness of gunpowder. The mechanical performance of similar machines never bears a proportionate relation to their size. If matter thus exhibits different modes of action according to the degree of its division, why may it not even think under a still finer division? It will be best to put away the explanations of these philosophers, and rest upon the simple declaration that consciousness can not be explained as the result of any arrangement or motion of the physical atoms of matter.

I have to say, besides, that we can not at present go further with Leibnitz. He concludes, from the incomprehensibility of consciousness from a mechanical basis, that it is not produced through material causes. We are satisfied with recognizing the incomprehensibility, which we may illustrate by saying that it is of a similar character with the impossibility of understanding why the twitching of the trigeminal nerve provokes infernal pains, while the excitation of certain other nerves is pleasant. While Leibnitz rejected consciousness in the soul-monads imparted to the body, and supposed a series of dream-pictures corresponding with the events of the body to pass along in it under God's direction, we are accumulating the proofs that consciousness is bound to material antecedents.

I name—not with full conviction—as the sixth difficulty, intelligent thought and the origin of language. An immense gap indeed exists between an amœba and a man—between a new-born child and a man; but it may be filled to a certain extent by transitions. The theory of knowledge apparently requires only memory and the power of generalization to make the way from simple sensation to the higher degrees of mental activity. Great as is the leap still to be taken between the faculties of the highest animal and those of the lowest man, the difference between them, consciousness being once given, is of quite another kind from that which opposes the mechanical explanation of consciousness. The latter problem and the former one are incommensurable. Therefore, to use Strauss's notation again, if problem B is solved, problem C does not seem to me to be transcendent.' Problem C, however, is closely connected with another problem, the seventh and last one in our series—the question of the freedom of the will.

It is natural that all the problems enumerated here should have busied mankind as long as it has thought. The constitution of matter, the origin of life and language, have been subjects of disquisition among all civilized peoples at all times. Yet only a few minds have advanced to these questions, and the report of the discussions of them

has seldom passed beyond the halls in which they were carried on. It has been different with the question whether man is free in his acts, or is driven by an unavoidable compulsion. This question—touching every one, apparently accessible to every one, intimately connected with the fundamental conditions of society, reaching to the depth of religious convictions—has played a part of immeasurable importance in the history of thought and civilization, and the stages of the development of the human mind are plainly reflected in the discussion of it.

Classical antiquity did not rack its brains very much over this problem. Neither the idea of an inviolably binding law of nature nor that of an absolute control of the universe existing in the general ancient view of the world, no ground was offered for a conflict between free-will and the governing principle of the world. The Stoics believed in a fate, and therefore denied free-will. The Roman moralists, from ethical considerations, set up the doctrine of freedom again on a natural subjective basis. "*Sentit animus se moveri*," Cicero remarks in the "Tusculans"; "*quod quum sentit, illud una sentit se vi sua, non aliena moveri.*"

It was Christian dogmatism that fell into the darkest self-dug pits over this question. The hopeless, entangling controversy about free-will and predestination has dragged along from the fathers of the Church through all the schools of doctrine and thought to the Reformers, and from them on. God is almighty and all-knowing; nothing comes to pass that he has not willed and foreseen from eternity. Therefore, man is unfree; for, if he had done otherwise than as God had foreordained, then would not God have been almighty and all-knowing. Thus it does not lie within man's will whether he do right or sin. How, then, can he be responsible for his acts? How can it agree with God's justice and goodness that he punish or reward men for acts which are fundamentally God's own acts? Such is the form in which the problem presented itself to those minds. The doctrine of original sin, the questions of redemption through merit or through the blood of the Saviour, by faith or by works, and of the different kinds of grace, were complicated in a thousand ways with that dilemma itself, already fruitful in subtilties, and the cloisters of Christendom resounded from the fourth to the seventeenth century with disputations about determinism and indeterminism. Perhaps there is no subject of human thought concerning which more has been written. The contest was not always confined to books, but often culminated in bitter accusations of heresy with all their horrors.

How differently is the problem of free-will regarded in our time! The persistence of energy proves that force ever arises or is extinguished as little as matter. The condition of the whole world, even of a human brain, at each instant, is the absolute mechanical result of the condition in the previous instant and the absolute mechanical cause of the condition in the following instant. That in a given instant one

or the other of two things may happen, is unthinkable. The brain-molecules can only move in the determined way; and, if one of them should wander from its place or path without an adequate cause, it would be as great a wonder as if Jupiter should break out from its orbit and throw the planetary system into confusion. If, as monism conceives, our conceptions, efforts, and volitions are really incomprehensible, yet necessary and unequivocal companion-manifestations of the movements and environments of our brain-molecules, there is evidently no freedom of the will. To monism the world is a mechanism, in which there is no place for free-will.

Leibnitz was the first to whom the material world was presented in this form. His mechanical view was quite the same as ours. He was acquainted with the persistence of energy, although he was not able to follow it through all the molecular processes, as we are, and stood toward collective molecular processes as we stand toward single ones. Inasmuch as Leibnitz also firmly believed in a spiritual world, brought the ethical nature of man within the circle of his views, and was on the best of terms with positive religion, it is well to inquire what he believed concerning free-will, and how he was able to reconcile it with the mechanical view of the world.

Leibnitz was obliged by his whole teaching to be an absolute determinist. He accepted two substances as created by God, the material world and the world of his monads. One can not act upon the other, but the processes go on in both under an unalterable, foredetermined necessity, quite independent of each other, but keeping an exact, harmonious step; the mathematically calculable oscillations of the world-machine, and, in the soul-monads appertaining to each animated individual, the conceptions that correspond with the apparent sensual impressions, volitions, and conceptions of the host of the monad. The very name of pre-established harmony, which Leibnitz gives to his system, excludes freedom. The conceptions of the monads being mere dream-pictures without mechanical cause or connection with the bodily world, it was easy to explain the subjective conviction of freedom by supposing that God has so ordered the flow of the conceptions of the soul-monad that it believes it is free to act.

On another occasion Leibnitz more closely followed the customary line of thought in allowing to man an appearance of freedom behind which a secret compelling impulse is concealed. Considering in his "Theodicy" the famous paradox, attributed to Buridan, concerning

> "... the old gray friend
> Which between two bundles of hay"

miserably starved because everything was alike on both sides, and he, as an animal, had no free-will, Leibnitz admitted that, if the case were possible, one would have to decide that he would allow himself to die of hunger; but he held that the case was fundamentally an instance

of the impossible, unless God should bring it about designedly; for the whole world could not be so halved by a perpendicular plane bisecting the ass lengthwise that all should be equal on both sides. Neither the parts of the world nor those of the ass could be so laid out. "There would also always be many things within the ass and without him which, although we may not remark them, would eventually determine him to turn to one side or the other. Although man is free, which the ass is not, the case of a perfect balance of the motives for two determinations appears to be impossible in him also; and an angel, or God, would always be able to provide an occasion for the conclusion taken by the man, even though, on account of the far-reaching concatenation of causes, that occasion is often very complicated and incomprehensible to ourselves."

Leibnitz availed himself of his optimism to find a place in determinism for the responsibility of man and the righteousness of God. Carrying out a fiction of Laurentius Valla, he describes in his "Theodicy" how sad it was for Sextus Tarquinius to be obliged to commit offenses for which punishment could not be spared him. Many worlds were possible in which Tarquinius might have played a more or less respectable part, have lived happily, and even have died in honor, full of years and lamented; but God was constrained to create this world, in which Sextus Tarquinius should be a villain, because in his foresight it would be the best, and the good would be in it, on the whole, at the maximum.

Monism can not derive any benefit from this idea, which, though consistent with itself, is decidedly arbitrary and bears the stamp of the unreal, and it must seek for itself its own position with reference to the problem of free-will. When one has resolved to declare the subjective feeling of free-will a delusion, it is as easy to reconcile apparent freedom with necessity on monistic principles as by extreme dualism. The fatalists of all periods have found no difficulty in it; and the feeling that was described by Cicero may be disputed away by one possessing a moderate dialectic versatility. Even in dreams, we feel free, while the phantasms of our sense-substances are still playing with us. We know now, of many acts that are apparently performed deliberately because they seem to have a purpose, that they are the involuntary effects of certain arrangements of our nervous system, of the reflex mechanism, and of the so-called automatic nerve-centers. When we watch the flow of our thoughts, we soon remark how independently of our will fancies come, pictures shine out and are extinguished. Need our supposed willful acts really be much more voluntary? If, moreover, all our sensations, efforts, and conceptions are only the product of certain material processes in our brain, then the molecular movement with which the volition to raise the arm is connected and the material impulse that causes the raising of the arm in a purely mechanical manner correspond, and there is no obscurity about it.

Obscurity comes over the view when the physical sphere is exchanged for the ethical. It is easy to admit that man is not free, but acts as the tool of hidden causes, so long as his conduct is indifferent. Whether Cæsar in thought put on his right or his left *caliga* first was all the same; in either case, he went out with his boots on. Whether he crossed the Rubicon or not, on that hung the world's history. So little are we free in some unimportant matters, that one acquainted with human nature can predict with surprising certainty which card out of several laid down under certain conditions we will take up first. But even the most decided monist could hardly adhere to the earnest purposes of practical life in the face of the idea that all of human existence is a *fable convenue* in which mechanical necessity awards to Caius the part of a traitor, and to Sempronius that of a judge; and therefore Caius is taken to execution, while Sempronius goes to his breakfast. We are not troubled that so many letters in every hundred thousand miscarry because they are not directed; but it stirs our moral feelings to think that, according to Quetelet, so many persons in every hundred thousand are to become thieves, murderers, and incendiaries; for it is painful to have to feel that we are not criminals only because others, instead of ourselves, have drawn the black lots that might have fallen to our share.

Less known than the metaphysical efforts to reconcile free-will and the moral law with the mechanical order of the world are the mathematical essays directed to the same end that have lately been put forth in France. They are related to the unsuccessful attempt of Descartes to explain the working of the soul upon the body, of the spiritual upon the material substance. While Descartes held that the quantity of motion in the world was constant, and did not believe that the soul could produce motion, he nevertheless thought that the soul might determine the direction in which motion should take place. Leibnitz showed that not the sum of motions but the sum of motive forces is constant, and that also the sum of the directive forces, or of the advance in the line of any axis projected in space, continues the same. He, therefore, called the algebraic sum of all those axes parallel components of all mechanical movements. According to the last point, which was overlooked by Descartes, the direction of motion can not be determined or changed without a corresponding expenditure of force. However small we may imagine this expenditure of force to be, it forms a part of the mechanism of nature, and can not be ascribed to the spiritual substance.

The deceased mathematician, Cournot, M. de Sainte-Venant, and Professor Boussinesq, of Lille, have undertaken to break the bands of mechanical determinism by showing that motion can be produced, or the direction of motion can be changed, without the expenditure of force. Cournot and M. de Sainte-Venant have applied the idea of release (*Auflösung*, Fr. *décrochement*), which has long been current in

the German physiological school. They believe that the force necessary for the release of absolute motion may be not only relatively very small, but even equal to nothing. M. Boussinesq has indicated certain differential equations of motion, the integrals of which permit singular solutions of such a kind that the sense of further motion becomes equivocal or quite indefinite. An example of this kind is the case in which a grave point at the periphery of a perfectly smooth paraboloid, having a perpendicular axis and its apex pointing upward, retains, in ascending in a plane drawn through the axis, the tangential velocity which it had acquired in falling to the same place. It then reaches the apex with a velocity of zero, and remains there till it pleases some directing principle residing there to give it an impulse in a required direction, which, although it is equal to nothing, shall yet be competent to let it glide down the paraboloid again.

Cournot believed that the releasing force, equivalent to zero, M. Boussinesq that the integral, with singular solutions, was needed as a means of explaining, in connection with the directing principle, the diversity and indeterminableness of organic processes. The German physiological school, accustomed to see only simple mechanism in organisms, hesitates to make friends with this conception, fearing, notwithstanding the protestations of its friends, that the vital force that is always, under one form or another, coming to the surface in France might be lurking behind the "directing principle." I may remark here that M. Boussinesq misunderstands me when he makes me say in the "Grenzen des Naturerkennens" that an organism is distinguished from a crystalline form only by its greater complication. On the contrary, I attach importance to having precisely designated the condition in which are grounded all the sensible differences that have caused mankind to recognize, although the same forces rule in both, two distinct kingdoms in living and inanimate nature. This condition is, that, in the inorganic individual, the crystal, matter exists in stable equilibrium, while in the organic individual a more or less complete dynamic equilibrium sways the matter, sometimes with a positive, sometimes with a negative balance. While the stream of matter coursing through the animal promotes the conversion of potential into kinetic energy, it also explains the dependence of life upon external conditions, the integrating stimulus of the older physiology, and the perishability of the organism as opposed to the eternity of the crystal lying inert in itself.

In our opinion, the theory of an unconscious life can subsist without a forking integral and without a directing principle. On the other hand, it is doubtful if anything can be gained in the controversy bebetween free-will and necessity with these aids or with the theory of release. M. Paul Janet's report to the *Académie des Seiences Morales et Politiques* admits the possibility of a mechanical indeterminism on the authority of the three mathematicians. But, when the hypothesis

that the releasing force may be infinitely small passes to the assertion that it may be really null, it seems to make an unwarrantable use of a process in the infinitesimal calculus which is usual under quite different conditions. The former statement can only mean that the releasing force may be vanishingly small in comparison with the released force. The force of the wing-flapping of a crow which starts an avalanche thus vanishes in the face of the force of the avalanche as it finally plunges through the valley; that is, the former may be neglected in the measurement of the latter, because the influence it exerts can not be indicated by any figures, and because it may fall within the range of errors of observation. But, however insignificant, as regarded from the valley, the wing-flapping above may seem in comparison with the mad force of the avalanche, it is still, there, a blow which corresponds with the raising of a definite weight to a definite height. By the nature of the escapement, the releasing and the released force are independent of each other, connected by no law. Hence it is inaccurate to say that "the ratio of the releasing force to the released force approaches zero," without adding that this depends on an accidental increase, so far as relates to the former, of the latter; as in our example, the wing-stroke being the same, the increase depends on the greater height, steepness, and smoothness of the mountain-slope, on the ever-mightier piling up of snow, etc. So little can the releasing force be in itself really null, it can never, unless we deny the releasing, fall below a certain something (*Schwellenwerth*) capable of an expansion that is dependent on circumstances. Therefore, to explain by the aid of the principle of escapement how a spiritual substance can effect material changes, is not to be thought of.

As to the solution proposed by M. Boussinesq, the grave point remains at the stationary position simply in unstable equilibrium, and it was not necessary to raise it by integration to calculate the consequences of that situation. The case, in fact, differs only in its abstract form of expression from Buridan's or Dante's paradox, which may be so formulated that the hungry creature—

> "*Intra duo cibi distanti e moventi*
> *D'un modo*—"
>
> ("Between two kinds of food, both equally remote and tempting")—

is in unstable equilibrium. No "directing principle" of immaterial nature is competent to move the grave point at the apex of the paraboloid in the slightest degree; a mechanical force, though it be ever so little, is necessary even upon a wholly frictionless surface. If this could be a force equivalent to nothing, then our second transcendental difficulty, of the origin of motion, would disappear at once; for an impulse equivalent to nothing would never be wanting.

M. Boussinesq also brings up the question of what would be the consequence of the reversal of all the motions of the world. If we

could imagine the mechanism of the world to consist only of reversible processes, and that at a given instant the motions of all the particles of matter were reversed as a ball is knocked back, then the history of the material world would play itself over again backward. All that now happens would come to pass again after its time in the inverse order: the hen would become an egg again, the tree would grow backward into a seed, and after an infinite time the cosmos would be resolved again into chaos. What processes would now attend the reverse movements of the brain-molecules? If mental conditions depended only on arrangements of atoms, then with the same arrangements the same conditions would return, leading to surprising results; among them, that, always at the instant before we contemplate anything, the counterpart of it would happen. We may, however, spare ourselves from estimating the possibilities thinkable here. The crank of the world-machinery could not be thus turned backward. The motion of masses, for instance, which has been converted by friction into heat, could not be changed back again into the same amount of similarly adjusted, opposite-faced motion. The reversed world is a bit of impossible mechanical fancy-work, from which nothing can be drawn respecting the origin of consciousness and free-will.

Our seventh difficulty becomes no longer a difficulty, provided we determine to deny free-will, and to declare the subjective feeling of freedom a delusion; but otherwise it must be regarded as transcendent; and it is but a poor consolation to monism that it sees dualism entangled in the same net the more helplessly as it lays more stress on ethics. In this sense I once wrote, in the preface to my "Untersuchungen über thierische Elektricität" ("Researches on Animal Electricity"), the words upon which Strauss now appeals against me: "Analytical mechanics reaches to the problem of personal freedom, the solution of which must remain an affair of the abstractive faculty of each individual." But afterward—and I make no secret of it—the day of Damascus came to me. Repeated reflections on the subject of my public address, "Ueber einige Ergebnisse der neueren Naturforschung" ("On some Results of the Later Natural Philosophy"), led me to the conviction that at least three transcendental problems precede the problem of free-will, viz., besides the problem of the origin of matter and force, which I have previously defined, that of the first motion and that of the first sensation, in the world. That the seven world-problems have been counted out and numbered here as if in a mathematical book of examples, has come to pass in consequence of the scientific *divide et impera*. We might combine them into a single problem—the world-problem. The mighty thinker whose memory we honor to-day believed that he had solved this problem. He had arranged the world to his satisfaction. Could Leibnitz, standing on his own shoulders, take part in our reflections to-day, he would surely say with us, "*Dubitemus.*"

# HOW ANIMALS BREATHE.

By HERMAN L. FAIRCHILD.

## I.

ANIMAL COMBUSTION.—Within every living organism there are two opposing forces. The "vital force," which produces all the phenomena of life, holds the material elements in unstable relations—against their will, so to speak—and it is antagonized by the natural chemical affinities of the elements, which tend to break down the organic compounds and rearrange the elements in more stable form. This decomposition takes place in some degree during the life of every organism, and when life ends, or when the vital force ceases to act, it rapidly destroys the structure.

The waste matter resulting from this disintegration must be immediately removed from the body of the living animal, otherwise it clogs and poisons the system. The method of its accomplishment is one of the most admirable functions of the animal economy. To remove the effete matter in the natural liquid or solid state would be very exhausting; consequently it is burned, and the gaseous products of its union with oxygen are then easily carried away. Literally speaking, this makes a furnace of the body of every animal; and the most pressing and ceaseless demand of the system is for oxygen to support its fires. Respiration is hence an absorbing and excreting process, whereby oxygen is received and carbonic acid and water removed. It thus becomes a measure of the amount of combustion.

In the "cold-blooded" animals respiration bears a direct proportion to the activity and the heat of the body, as the former causes a metamorphosis and waste of tissue, and the latter always aids decomposition. The fact is one of common observation. It is well illustrated in the quickened breathing of a tired animal, and in the almost entire suspension of respiration in the hibernating state. The respiration of a "cold-blooded" creature is increased by artificial heat. In

FIG. 1.—COBITIS FOSSILIS. It swallows air-bubbles which pass through the intestine, where the mucous membrane takes up the oxygen for respiration.

extremely hot weather frogs may have to leave the water entirely, and fishes come to the surface to procure air. Reversely, frogs can be kept for years in a state of suspended animation by a low temperature, and revived by warming. Some low animals can survive freezing or

drying for an indefinite time; and, under such conditions, the waste of the tissues must be entirely suspended.

In "warm-blooded" animals — birds and mammals — a constant body-temperature, independent of the surrounding atmosphere, is maintained by the immediate use of the food as fuel. Consequently, in a warm atmosphere less internal combustion is required than in a cold one, and the respiration of birds and mammals is therefore inversely proportionate to the external temperature, although directly proportionate to the activity of the animal.

This constant body-temperature is the reason of the difference in the kind and quantity of food required according to season or latitude. While the people of the tropics subsist chiefly on vegetable food, which supplies little fuel, but on the contrary much fluid to cool the body by evaporation, the inhabitants of frigid regions use carbonaceous foods affording the greatest proportion of fuel.

Experiments tend to prove that human respiration is, as would theoretically be expected, less rapid in the tropics than in the cold regions. Every traveler knows that a less amount of food is required. But on the contrary, and for the reason above stated, respiration in the cold-blooded animals is more rapid in the tropics, and the quantity of food is greater.

PHYSIOLOGICAL PRINCIPLE.—The process of respiration is in principle an interchange of gases between the fluids of the structure and the external medium, air or water. It should be unnecessary to say that aquatic animals do not breathe water, but the air which is absorbed by the water. This exchange is effected by the physical action known as osmosis. It is a question whether vital influence has any part in the process. The principle is identical in all creatures, air-

FIG. 2.—HOLOTHUROIDEA (*Thyone papillosa*). (After Forbes.)

breathers and water-breathers—those which have special fluids, or blood, and those having none. It applies to plants also, as far as they have a true respiration.

In bringing the internal and the external fluids adjacent, Nature in this function, as in all others, is nicely economical of power. In "water-breathers" the blood, when existing, is commonly sent to the surface of the body, and a slight movement of the water produced—sufficient to renew that in contact with the respiratory organs. But "air-breathers" always draw the mobile atmosphere inward to the blood.

Respiration of Plants.—The leaf-respiration, so called, of plants is not an excretory process, but rather a nutritive one. In effect it is precisely the reverse of true respiration. It is a deoxidizing process—separating the components of carbonic acid under the influence of the sun's rays, and depositing the carbon; whereas respiration is an oxidizing process—the production of carbonic acid. However, during germination and flowering, and in darkness, decomposition takes place within the plant, resulting in the production and elimination of carbonic acid—a true respiration.

Many biologists now hold that there is a constant decomposition of crude nutriment in the interior of plants, and therefore a slight respiration, but that it is masked by the more prominent nutritive process. The leaves are commonly, but wrongly, called the lungs of the plant, for their chief function, as we observe, is not respiration, but nutrition. It were more correct to regard them as the stomach of the plant.

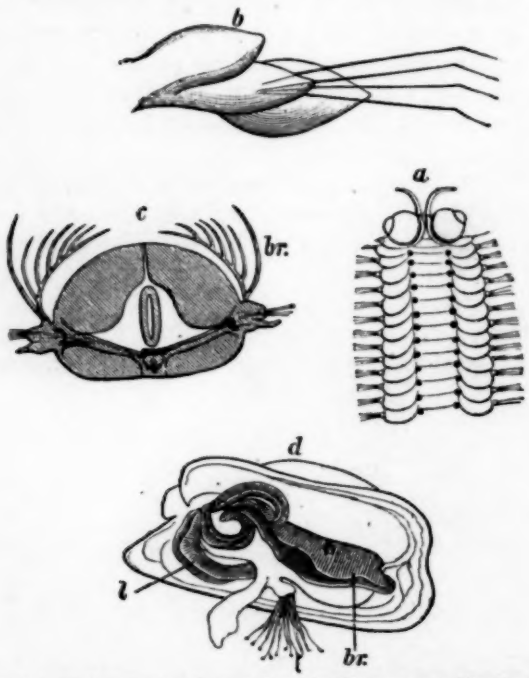


Fig. 8.—Gills, *a*, *b*, *c*, of Annelida; *d*, of a Bivalve Mollusk. *a*, *Naupkanta ceiox* (Greeff), enlarged to three diameters, with broad gill-fins. *b*, foot of *Vanadis ornata* (Greeff), with two broad gill-fins. *c*, section of a segment of *Eunice*; *br*, the ramified gill-appendages of the rudimentary foot. *d*, *Mytilus edulis*, with *br*, the gill-folds, and *l*, the lips separated from them.

Organs of Respiration.—As the function of respiration is so simple in principle, being a single physical action, it can be conducted almost anywhere in the body, or wherever the blood can be conveniently exposed to the surrounding medium. The nature of an animal, as regards other less easily modified functions, and its peculiar circum-

stances, may therefore greatly determine the character of its breathing-organs. So it results that these organs, in the various groups of animals, are exceedingly diverse in form, structure, and position. They are much more diverse, indeed, than are the organs of any other function, and any classification now possible is quite arbitrary.

In purpose, however, or *physiologically*, all breathing-organs are simply an expansion of surface for the more rapid aëration of the circulating fluids. And in origin, or *morphologically*, they are fundamentally a modification or development of the skin ; being developed either primarily, i. e., directly from the skin itself, or secondarily, i. e., from the alimentary canal, which is itself so derived.

The following tabular classification shows the general morphological character of the respiratory organs in the primary groups of the animal kingdom. While correct in the main, it does not cover all exceptional cases, but fairly exhibits the development of the organs and the "differentiation" of the function from the lowest to the highest animals. Except in the vertebrates no regard in this table is paid to any distinction between air and water breathing.

In explanation : A stands opposite the mode of respiration which is *characteristic* of the group beneath which the letter occurs ; and the diminishing degrees in importance of the various methods are indicated by the small letters according to the alphabetical order : but of course the same letter is not of equal value for different groups of animals.

The reader will observe the common use throughout the whole animal kingdom of the skin unmodified. Also that the special organs of the invertebrates, which number more than nine tenths of the whole, are quite limited to modifications of the skin ; while those of vertebrates belong only to the alimentary canal. The description to follow will adhere to the order of the table :

| RESPIRATION BY— | | Lower Protozoa (Rhizopoda). | Higher Protozoa (Infusoria). | Lower Radiata (Cœlenterata). | Higher Radiata (Echinodermata). | Articulata. | Molluscs. | Vertebrata. Fishes. | Amphibia. | Reptilia. | Aves. | Mammalia. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Special Organs, developed from | Food-tract. Lungs. | | | | | | | b | A | A | A | A |
| | Food-tract. Gills. | | | | c | e | | A | c | | | |
| | Skin (immense variety of organs). | | | | A | A | A | | | | | |
| General Surfaces of body without any important modification. | Food-tract..... | | b | A | b | d | d | c | d | | | |
| | Skin..... | | A | b | c | b | b | d | b | c | | e |
| Entire Substance of body. Respiration without organs. | ..... | A | | | | | | | | | | |

RESPIRATION BY THE UNMODIFIED SKIN AND FOOD-TRACT.—The general surface of the body has in all soft-skinned animals an aërating or respiratory action; and the simplest expression of *organs* is found in those animals where the body-surface is the only breathing-organ. But a simpler expression of the *function* is shown in an amœba, for example, where by the amœboid movements every part of the structureless body eventually becomes surface, and is brought into immediate contact with the water. The amœba has no permanent skin, and no organs of any kind; consequently it breathes without special organs, and the other nutritive functions are equally destitute of them.

FIG. 4.—TUBICOLA. *a*, *Serpula contortupicata*, showing the branchiæ and operculum; *b*, *Spirorbis communis*.

Many animals of higher groups breathe mainly or entirely by the skin. Among articulates, the leech and earth-worm are examples. In these a net-work of minute blood-vessels is spread beneath the delicate skin, thus bringing the blood into proximity with the water or air. The lowest crustaceans, and some sea-snails, and sea-spiders also, respire by the skin alone.

Most amphibians use the skin largely in respiration. In cold water, frogs will breathe entirely by the skin, and can not be killed by forced immersion, so long as they are provided with food. Even at ordinary

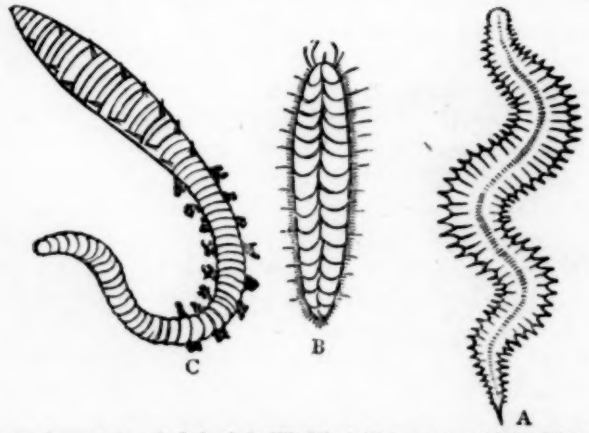


FIG. 5.—ERRANT ANNELIDES. A, hairy-bait (*Nephthys*); B, sea-mouse (*Aphrodite*); C, lob-worm (*Arenicola*). (After Gosse.)

temperature, it is easier to drown some fishes by preventing them from reaching air than it is to suffocate frogs under the same conditions; yet the former have only gills, and the latter lungs alone. The hell-bender, found in our Western rivers—the largest American salaman-

der—breathes entirely by its skin under ordinary circumstances. To expose more surface, the skin is greatly expanded, lying in ugly folds; while, to renew the contiguous water, the body is frequently arched and rolled from side to side, which motion, together with the aspect of the creature, has given it the above expressive name.

As the outer surface of the animal body may without any special modification have a respiratory function, so we find the same to be true of the food-canal. The body-cavity of the polyp and jelly-fish, with its tubes and branches, has in previous articles been described as the organ of digestion, circulation, and respiration in common.* Many

FIG. 6.—PHYLLOPODA. Fairy Shrimp (*Chirocephalus diaphanus*). (After Baird.)

annelids breathe partly by currents of water passing through the intestine. A slight modification of the lining of the food-tract is found in the larvæ of the dragon-flies, which, living in water, have respiratory villi in the rectum; and the sea-cucumber has foliated processes in its stomach, bathed by water-currents, which doubtless have a respiratory function.

Many fishes swallow air as an aid to respiration. In the loach (*Cobitis fossilis*), and numerous others, it is certain that this air traverses the stomach and intestines.

SPECIAL ORGANS OF THE SKIN.—Of the special breathing-organs we will first consider those which are developed directly from the skin. They are especially characteristic of the invertebrates, as they include all the special respiratory apparatus of that division of the animal kingdom, whether adapted for water or air, and they are not found beyond this group.

AQUATIC ORGANS OF THE SKIN.—The higher radiates and the lower articulates possess an arrangement of tubes and vessels known as the "water-vascular" or "aquiferous" system. Although the relation of these vessels to the circulation is not fully determined, it is probable that they are chiefly or entirely for the purpose of conveying water inward, and thus constitute respiratory organs. They are rendered necessary because of the undeveloped condition of the blood-circulating system. Like other cavities, they are only an inflection of the surface-tissue.

This aquiferous system is of very great complexity and variety, and full description is impracticable. It is at once greatly developed in the sea-urchin and star-fish; and is especially complex in the sea-

* Other articles in comparative physiology are contained in the "Monthly" of April, June, and September, 1880; and August and September, 1881.

cucumber, where it is connected with gill-like appendages about the mouth. The intestinal worms and other annelids possess this style of breathing-organs. Later we shall find in the insects a similar and perhaps homologous system for conveying air.

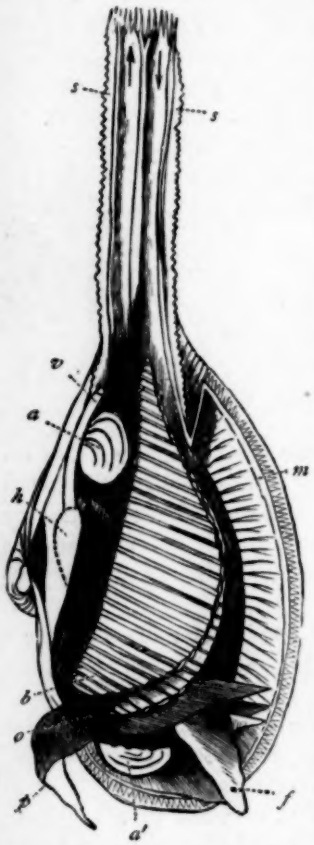


FIG. 7.—ANATOMY OF A BIVALVE MOLLUSK (*Mya arenaria*). The left valve and mantle-lobe and half the siphons are removed. *s s*, respiratory siphons, the arrows indicating the direction of the currents; *a a'*, adductor muscles; *b*, gills; *h*, heart; *o*, mouth, surrounded by (*p*) labial palpi; *f*, foot; *v*, anus; *m*, cut edge of the mantle. (After Woodward.)

Most aquatic invertebrate animals which have a true circulating fluid send this to expansions of the skin to be there oxygenated by the surrounding water. This is termed "branchial" respiration. The branchiæ or gills may be wholly exposed and external to the body, or may be contained in suitable cavities. They may develop on any part of the body; and they exhibit a great variety in many respects. With this system is frequently found some special accessory apparatus for producing and regulating a flow of water over the gills.

The sea-worms have a great variety of external gills developed immediately from the skin. Renewal of water is secured by cilia which cover the body or even the gills. These branchiæ are finely shown in the common *Serpula*, where they form a crown of scarlet plume-like about the mouth. The *Arenicola*, or sand-worm, has two rows of crimson rosettes along the sides of the body. The *Eunice*, *Nereis*, and sea- mouse, are other worms possessing beautiful arborescent fringes of branchiæ.

As the crustaceans, excepting a few of the lowest, are covered with a hard shell of dead matter, they can not respire through the skin, and hence of necessity require special organs. These are commonly leaf-like expansions, usually attached to the locomotive or other appendages; the purpose of such attachment being to secure rapid change of the surrounding water. In some groups, the entire limb becomes foliaceous and respiratory, so that it is literally correct to say that the fairy shrimp breathes with its legs. Other forms, including the sand-hopper, whale-louse, and fresh-water shrimp, breathe by vesicles or bladders attached to the limbs. The water-fleas, as *Cypris* and *Cyclops*, so common in our fresh waters, have their branchiæ attached to the jaws. Many forms, among which are the king-crab, or *Limulus*, and

the group of isopods, respire by foliaceous or feathery appendages beneath the abdomen.

The higher crustaceans—crabs, lobsters, and shrimps—have arborescent gills inclosed in cavities on the side of the thorax. They are at-

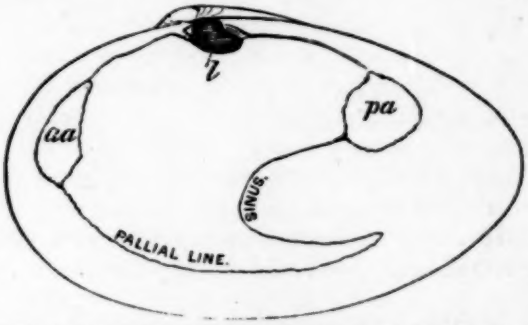


FIG. 8.—RIGHT VALVE OF A COMMON CLAM. (After Morse.)

tached to the bases of the legs, but the motion of the latter would here have little effect to renew the water. This is accomplished by a curious valve placed in the excurrent orifice of each chamber, which resembles in principle the screw-propeller of a steamship. The observer will find the excurrent orifice at the side of the mouth, and the incur-

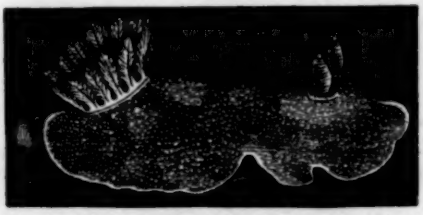

FIG. 9.—DORIS, OR SEA-SNAIL. (After Carpenter.)

rent orifice between the edge of the shell and the bases of the legs. Curious combs and brushes are provided to keep the gills clean and the filaments separate.

Bivalve mollusks, as clams, mussels, scallops, etc., have gills made of foldings of the "mantle" or skin. (See Fig. 10, page 467, of the August "Monthly.") There are generally two for each side of the

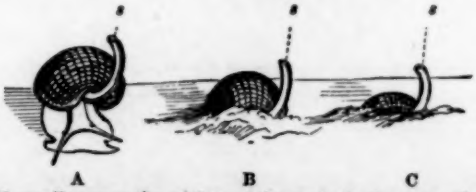


FIG. 10.—A, the snail crawling upon the surface of the mud; B, the same slightly buried; C, the same nearly buried; the siphon, *s*, is seen curved upward. (After Morse.)

body ; and their form has given to this class the scientific name *Lamellibranchiata*—plate-gills. The water bathing the gills is constantly renewed by means of *cilia*. "Wonderful, indeed, is the elaborate mechanism employed to effect the double purpose of renewing the re-

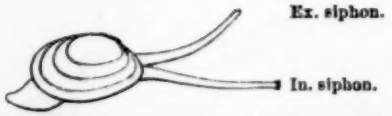


FIG. 11.—LAMELLIBRANCH, SHOWING TWO SIPHONS. (After Morse.)

spired fluid and feeding the helpless inhabitants of these shells. Every filament of the gill-fringe, examined under a powerful microscope, is found to be covered with countless cilia, in constant vibration, causing, by their united efforts, powerful and rapid currents. . . . So ener-

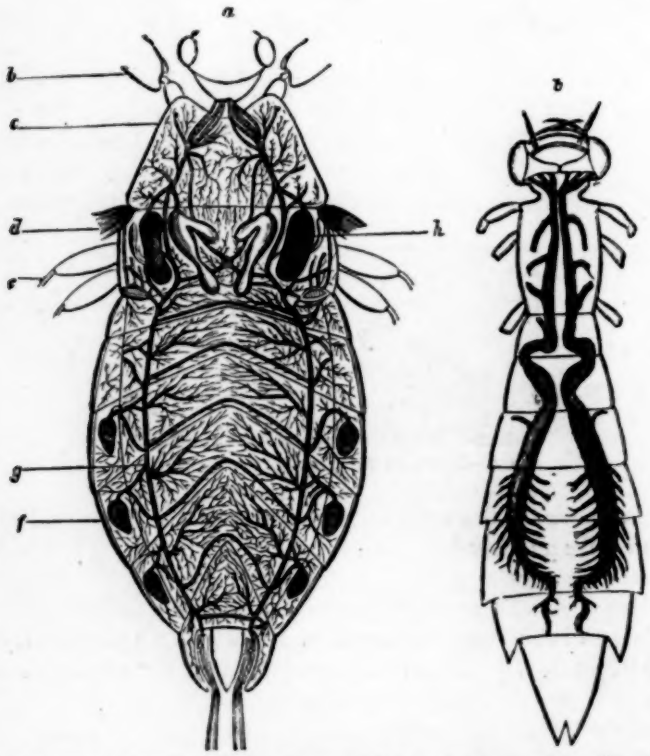


FIG. 12.—TRACHEAL SYSTEM INDICATED WITHIN THE OUTLINE *a* OF A WATER-BUG, *b* OF THE LARVA OF AN ÆSCHNA. The tracheæ are shaded.

getic, indeed, is this ciliary movement over the entire extent of the branchial organs that, if any portion of the gills be cut off with a pair of scissors, it immediately swims away, and continues to row itself in

a given direction as long as the cilia upon its surface continue their mysterious activity." *

In the oysters and scallops, the mantle is open, exposing the gills; while the mussels and giant *Tridacna* have the mantle closed but pierced with two apertures for the reception and expulsion of water. The remaining lamellibranchs, which include the common hard clam, razor-shell, pholades, and teredo, have long inhalent and exhalent tubes, called *siphons*, which enable the creature to burrow in the sand and still obtain water. The two siphons may be separate or united, and are retractile. The presence of such tubes can be determined by examination of a dead shell; as the muscles which retract the siphons produce an indentation or "sinus" in the "pallial line."

Perhaps the most conspicuous and beautiful gills are those possessed by the naked sea-snails or "sea-slugs." They are situated on the back and sides of the body, and are frequently retractile. In the *Doris* they have a flower-like or star-shaped arrangement. In the *Eolis* they are papilliform and tufted, along the sides of the animal, or they may be tree-like as in the *Triton*, or feathery in other forms. The *Aphysia*, or sea-hare, has the gills placed on the back and protected by a fold of the mantle. The *Phyllidia* have them as a fringe along each side of the body, and covered by a projecting fold of the skin; while the *Limpet* and *Chiton* have leafy gills forming quite an entire circle about the body, and also covered by the mantle.

FIG. 13.—AIR-PIPE OF FLY.

The sea-snails having shells carry their gills in cavities in the side of the neck, and may or may not have siphons. The possession of the latter is shown by a notch in the aperture of the shell.

All the mollusks mentioned thus far are sluggish animals, with little need of rapid respiratory changes of the blood. But the highest of mollusks, the cephalopods, or devil-fishes, are active and muscular creatures—the most powerful of invertebrates. They have accessory hearts to accelerate the flow of blood through the gills, which are large and plumose, and contained in a cavity. Water is freely sup-

* T. Rymer Jones, "The Animal Creation," page 194.

plied to the gill-chamber by the open mantle; but, by the contraction of the latter, the water is forcibly expelled through a tube termed the "funnel." This expulsion of water from the branchial chamber is their chief means of locomotion.

AËRIAL ORGANS OF THE SKIN.—Special organs developed from the outer surface of the body and adapted to air-breathing are confined to

FIG. 14.—SPIRACLE OF COCKCHAFER-GRUB.

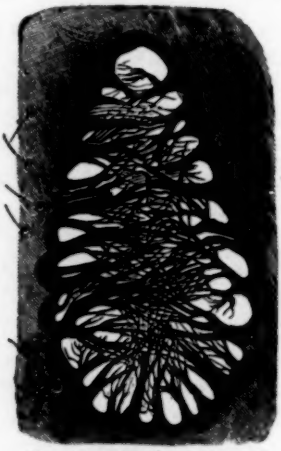

FIG. 15.—SPIRACLE OF FLY.

the articulates and mollusks. None are found in the radiates, this great division being wholly aquatic.

Although the crustaceans always possess gills, and are theoretically classed as water-breathers, yet certain species live entirely on land, and some are even killed by long immersion in water. The gill-chambers of the land-crabs are proportionately very large, exposing more surface to the air, and the openings are small to prevent evaporation. Some species inhabit the highest ground of West India islands, but they seek damp or sheltered places, and possess some means of keeping the gills moist, either by carrying a small quantity of water, or by a secretion of the sponge-lining of the chamber. Structurally these organs are gills, but functionally they are true lungs.

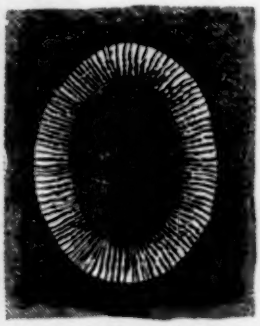

FIG. 16.—SPIRACLE LEATHER-COAT.

Another crustacean, the wood-louse (*Oniscus*), lives in damp places, and breathes air by foliaceous gills beneath the abdomen.

The only groups of articulates wholly air-breathing are the myriapods, insects, and arachnids. The myriapods show a transition from the skin-respiration of the leech and earth-worm to the air-tubes of the insect. The latter possesses the most peculiar and effective system for aëration. As in

the annelids a complex system of tubes conveys water to the tissues, so in the insects all parts of the body, and the nutritive fluid, are bathed by air admitted through a complex tube-system. So complete is the aëration of the whole structure, that practically the blood of an

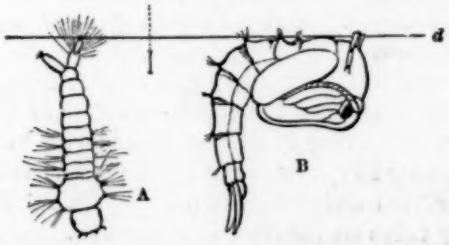


FIG. 17.—A, lava; B, pupa of a mosquito. *d* represents the water-line. (After Morse.)

insect is wholly arterial. The necessity for this lies in the slow and imperfect circulation, coupled with an unparalleled activity.

The air-tubes, "tracheæ," traverse every part of an insect's body, even the brain and eye, and form the nervures or frame-work of the wings, where they are sheathed by another tube conveying blood. They are prevented from collapsing by a mechanism, one of the most admirable and exquisite found in nature. A delicate, elastic thread is wound in a close spiral between the two membranes of the walls of the tubes—a contrivance which we have imitated in the flexible gas-tube of a drop-light.

FIG. 18.—GRUB OF CHAMELEON-FLY.

The openings to the tracheæ, termed "spiracles" or "stigmata," are generally located on the sides of the abdomen and thorax, a pair for each segment, and exhibit great variety and adaptation to their purpose. So constructed as to admit air, they exclude water and dust, and can be opened and closed at the will of the creature. Sometimes they are a mere slit, like a buttonhole. In the soft-skinned larvæ they are kept open by a horny ring. The aperture is sometimes protected by interlacing hairs; sometimes it is grated, or in other species closed by a thin membrane pierced by innumerable small pores—a real sieve. A drop of oil placed upon the abdomen immediately fills the spiracles and smothers the creature.

The change of air is produced in the tracheal system by the enlargement and contraction, or bellows-action, of the abdomen, the segments sliding in and out with a telescopic movement, very perceptible in the larger insects.

Many insect larvæ live in water, but are still air-breathers. The mosquito is an example. Here the eighth joint of the abdomen sends off a long tube, crowned at the extremity with feathery bristles, which are brought to the surface of the water to seize a drop of air. With this the larva descends and the repellent action of the setæ prevents the water from dissolving it. Some water-larvæ have tubes several inches long. Other larvæ, destitute of tubes, have the spiracles at the posterior end of the abdomen. In the pupa state the mosquito has two respiratory tubes on the back of the thorax.

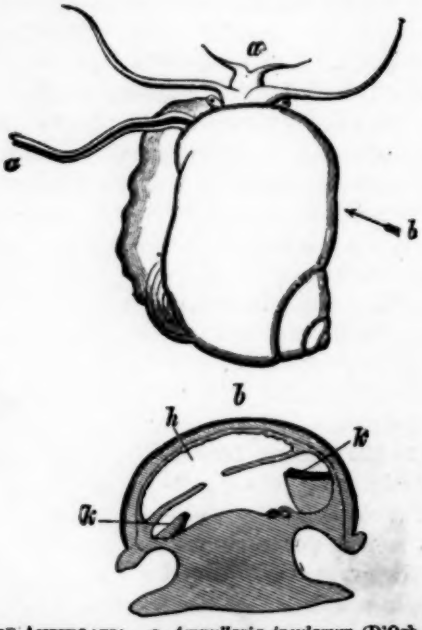


FIG. 19.—GILL-LUNGS OF AMPULLARIA. *a*, *Ampullaria insularum* (D'Orb.). *a*, long respiratory siphon; *b*, section in the direction of the arrow *b*; *h*, the upper lung-cavity; *k*, branchial cavity with the right and left gills; the cavities communicate by a passage in the center of the dividing wall.

The aquatic larvæ of the dragon-flies (*Libellulidæ*) have, as already mentioned, hair-like processes, "villi," of the lining of the rectum, which absorb air from the water and convey it into the tracheal system. It is difficult to determine if such larvæ should be regarded as aquatic or aërial. Certainly in their habits, and in their method of procuring oxygen, they are aquatic and possess gills. But the oxygen is not immediately given to the blood in the villi, as in true gills, but is conveyed through tracheæ just as in adult insects. On the latter account these larvæ are generally considered aërial.

Adult water-insects carry air into the depths of the water by holding it under the wings or legs, or by the minute hairs which cover the body. This frequently gives them the silvery appearance of a globule of mercury, and sometimes renders the creature so buoyant that it has to descend by muscular effort—swimming downward, or crawling down a plant-stem.

Insects of powerful flight have sacs developed on the tracheæ, which doubtless serve to store air, and also to render the body lighter.

Spiders lack the tracheæ, but have the spiracles opening directly into sacs. These are various in structure, sometimes folded like gills, or in other cases cellular, like a rudimental lung in structure.

Among mollusks only the true snails are air-breathing, and some of these inhabit water. They have organs resembling those of the spider, concentrated into a single sac. This is lined with blood-capillaries and constitutes a true external lung. The orifice opens on the right side of the neck, and can be closed by a circular muscle.

In the pond-snails we have a clear illustration of the identity in principle of air and water respiration. For, in the *Lymneæ*, the sac, which in the early stages of the animal breathes water alone, can suddenly change to a lung, and thereafter breathe only air. And in specimens from deep water the change may occur in the adult animal. The *Ampullariæ* have the breathing-sac partially divided into an upper or air chamber and a lower or gill cavity; using first one and then the other, or breathing air and water alternately at intervals of a few minutes.

## DREAMS AND THE MAKING OF DREAMS.

By J. MORTIMER GRANVILLE, M D.

DREAMS are night-thoughts, unchecked by the judgment and uncontrolled by the will. It is not true that we do not reason in dreams, that the exercise of the judgment is wholly suspended, and that the will is entirely powerless or ceases to act. These faculties are not altogether in abeyance, but they doze while the subordinate powers of the mind—those which play the parts of picture-carriers and record-finders—ransack the treasures of memory and mingle together in the direst confusion old things and new. Imagination is not active, but it remains just enough awake to supply the connecting links which give seeming continuity to those parts of the phantasmagoria which we chance to remember on recovering perfect self-consciousness, and which, being remembered, we call "dreams." No one remembers more than one dream, unless he has roused from sleep more than once. This experience has led to the inference that dreams only occur at the

moment or in the act of awaking. There are dreams which take place in the process of returning to consciousness—for example, those instantaneous scenes and spectacles which are suggested by the sound or feeling that rouses the dreamer; but, in result of a long and close study of the subject with a view to discover the nature of dreams, and the laws of dreaming, for medical purposes, in connection with the treatment of sleeplessness, I am persuaded that dreams occur in the course of sleep and are wholly forgotten.

That they do not and can not take place in deep sleep is probable, because deep sleep is general sleep, and when this state prevails the subordinate faculties are sleeping, and the pictures and records which compose dreams are not disturbed. To understand dreams we must understand sleep, and it is because the two phenomena have not hitherto been studied together that so little is generally known about either.

Sleep is a function or state in which the particular part of the organism sleeping *rests:* whether it is wholly inactive depends on the degree of rest it enjoys. Every part of the organism sleeps, and the totality of the sleep-state depends on the fact of all the important parts sleeping at the same time. If some remain awake—perhaps busy with an unfinished task, or setting about one which the will has foolishly imposed on one of the lower faculties before itself going to sleep, or, it may be, too worried to take natural rest—then the unrest of the busy or distressed faculty or faculties will render the sleep as a whole incomplete, and the repose of the actually sleeping faculties disturbed. Natural sleep is simultaneous sleep of all the faculties of body and mind; and the secret of sleeping soundly and restfully consists in so ordering the life that the higher intellectual powers, the powers of automatic activity, the senses, the muscular system, and the viscera—principally the stomach—may all be ready and able to sleep at the same time. This can only be accomplished by making the act of sleep a thing done periodically, with that rhythmical regularity which Nature loves and on which the smooth working of the machinery of life depends. When sleep is natural, in the sense of being complete, dreaming is, as we have said, improbable, if not impossible; and the measure of dreaming is therefore—inversely—the measure of the integrity of the sleep enjoyed. A great dreamer can not be in good health, or, to use a familiar expression, he "can not have all his wits about him" when he is awake. Every faculty—by which I mean, every part of the organism which performs a distinct function—must sleep; and, if it be healthy, it will sleep at regularly recurring periods. It follows that a dreamer who is not unhealthy—a *rara avis*—must have formed the habit of allowing his faculties to sleep separately; some being on duty, or watching, while others rest. As a matter of fact, most persons form this habit to some extent, and therefore the majority dream. For example, the man who works with his brain often takes little muscular exercise, and

his apparatus of motion rests and doubtless sleeps while his mental faculties are in full action. It may happen that the development of this habit of separate sleep is carried to such an extent that the several centers of the brain habitually take their rest independently of each other, and at different times. The clerk will doze as he adds up his column of figures; and the copyist will go on transcribing while his centers of thought and imagination sleep. Conversely, the lower and automatic centers of the brain—the senses—may sleep while the higher centers are awake. Much of the so-called "abstraction" and "absence" of mind we notice in ourselves and others is due to this cause. The brain-worker gains credit for being lost in thought when he does not perceive some object which ought to impress him strongly through one or more of the senses; the farmer toiling over his fields, the hunting-man weary with his day's work, the soldier exhausted by the toil of the march, will sleep so far as one set of faculties, or one part or system of the organism, is concerned, while the others are not only active, but so controlled that the subject of this partial sleep may walk or ride or go through evolutions while his mind sleeps. In short, it is possible, and easy, to fall into any habit of this class, and the inevitable consequence will be that only some of the faculties, or parts of the organism, are ready to sleep when night comes round, while those which remain awake will be unrestful and disturb the others so that they can only doze. In this state of matters, dreaming is an unavoidable experience. Meanwhile, the most highly developed and dramatic dreams occur to those whose sleep is so partial that part only—and, as it would often seem, a small part—of the brain sleeps at any time; or, perhaps, I ought to say, at night—because it not unfrequently happens that those who dream much by night do not dream when they sleep by day. This variety of partial sleep, which tends to sever the natural connections between the several component parts of the mind, is injurious, and therefore it is, as I have remarked incidentally above, that great dreamers are, as a rule, unhealthy. It is easy to see how this must be. If the intellectual faculties are, so to say, broken up in such a way that when some are active the others are sleeping, the checks and restraints which the several parts of the mind naturally impose on each other are wanting, and any one of the faculties may become exaggerated in the exercise of its functions. The practice of dreaming will then extend to the day, and the mind may—especially if there be any inherited and constitutional lack of cohesion among the intellectual faculties—become disorganized. This is a contingency, or more than a contingency—let us say, a probability—against which the dreamer of particularly "worked-up" or realistic and elaborate dreams should be on his guard. It does not, however, follow from what I have said that the most *coherent* dreams are the worst, because the judgment may be simply dozing, and able to correct the scene or story as it passes through the mind. In that case, the sever-

ance between the higher and lower faculties will not be so great as when the incongruities of the dream are unchecked, and yet the pictures and thoughts present to the mind are especially clear and strong in their outline and coloring. Intensity without coherence is, as a rule, worse than an equal amount of vivid dreaming with more connectedness of thought. We now know something, though a very little, in truth, about dreaming, and we may pass to the consideration of our proper subject—dreams and the making of dreams.

Dreams are re-collections, in the strict sense of that word. The pictures which have been put away in the chambers of mental imagery, the thoughts which have been recorded, as all thoughts are recorded, by the molecules of the brain in the act of thinking, the impressions left by perceptions made by the organs of sense, and by conceptions originated by the faculties of mental sensation, impressions of feeling, together composing the records of experience, are brought out of their holes and corners, and, as it were, thrown crudely before the mind. There is seldom any clear evidence of order in the arrangement, but there is no reason why, if the collecting faculty be thoroughly awake, it should not follow beaten tracks, and arrange the pictures and records it reproduces in their natural sequence. Moreover, there is that association of ideas which forms the basis of memory, and this will almost necessitate a certain amount of connection between the elements of the most chaotic dream. All that seems to be original in a dream is due to the kaleidoscopic effect of throwing the materials of which the scene is constituted into new and startling combinations. We know how much of novelty may be produced in the accidental combinations effected by shaking together some dozen particles of colored glass, or other small objects, in a kaleidoscope. The variety will be greater and the new combinations more surprising in the throwing together of memories in a dream, because the natural associations help to give *vraisemblance* to the effect, and the imagination, which is seldom wholly asleep, gives finishing touches to the panorama as it proceeds. Much less, however, is due to the intervention of fancy in a dream than is commonly supposed. The great majority of the results produced are caused by the overlapping of pictures, the entangling of threads of thought, and the distortion of the original connections between ideas, pictures, and records of impressions which have either been received or put away together, or connected in previous dreams. For dreams are often, wholly or in part, reproductions of former dreams, and in process of years a mind may become expert in, or habituated to, the experience of a particular class of night-visions and night-thoughts. Dreams may be roughly divided into four classes: 1. Those of the present; 2. Those of the past; 3. Those of the future; and, 4. Dreams which would appear to be simply heapings together of inchoate ideas and mind-pictures, without either time, order, method, or reason. On each of these classes of dreams there

is something to say, but it must be said briefly, and rather by way of suggesting inferences to other minds than in argumentative support of my own conclusions.

First, as to dreams of the *present*—it is important to note that, though these are seldom precisely what they seem, when there is a tendency to employ very recent mental pictures, records, and impressions as the material of dreams, the faculty engaged in dream-making is either jaded or lethargic. Thus we get the same result, as regards the constituents of the dream, from two opposite causes. When that part of the brain which performs the function of re-collecting the records of memory is very weary—perhaps too distressed by excessive or disorderly work to sleep—it worries the mind with the subjects of immediately previous attention, being unable to leave them, and busying itself with them in a purposeless and distressful way, as a somnambulist or very sleepy person labors at a task he is unable to leave. The result will be a dream consisting of thoughts and scenes and impressions of the scenes which, as it were, cling to the mind and will not be dismissed. There are, doubtless, especial states of the mind, or its organ, the brain, which may be loosely described as "sticky," and which create a strong tendency to dally with objects of thought, and hold impressions of the senses before the consciousness longer than is necessary, instead of putting them away promptly in the memory. We know how the clumsy-fingered or bewildered workman clutches his tools and hangs over his task instead of using each tool deftly, doing each stroke of work cleanly, and passing on to something else. The same faults of method are to be recognized in the operation of many of our mental faculties, and this is one cause of dreams constructed of recent materials. Dreams of this class, as would naturally be expected, are deficient in that characteristic which is due to an active play of the dream-making faculty with the materials it employs, namely, the quality of "originality." They are apt to be little more than worrying recitals of the words spoken, the books or letters read, and reproductions of the scenes and impressions of the previous day, without much modification or embellishment. When reminiscences of this nature occur at night in the false sleep that mocks real rest, they are likely to be exaggerated and intensified in an extraordinary and generally painful degree, simply because the mind is isolated by sleep from its immediate external surroundings, and all the energy of consciousness it evolves is, so to say, turned in on itself. Dreams of the present, produced by lethargy or exhaustion of the faculty which collects and reproduces the pictures and records of memory, are generally distinguishable by their tumultuous or oppressive character. The faculty is, as it were, overburdened by the subjects it strives to manipulate. It can neither bring them fully and clearly before the consciousness, nor can it remove them at pleasure. The mind does not so much itself hold them as feel oppressed by their presence. It

would fain be rid of the thoughts and scenes pressed on its attention, not because they create a painful interest, but because they bore it. On the other hand, dreams of the present, which are more directly due to the general state of mind previously described, take an agonizing hold on the consciousness, and will not be shaken off, so that it struggles to be free as in a state of mental nightmare. Dreams of the present which are produced by a lethargic rather than an exhausted state of the faculty that makes them, are characterized by the slow progression of scenes and the tardy flow of thoughts rather than repetition. The consciousness seems to be in a dreamy condition, while some slow and stupid exhibitor is unfolding a story or panorama lazily. The resulting feeling is one of simple fatigue from loss of rest, rather than the head- and heart-aching, as from worry and prolonged irritation, which follow on dreams of the present that have been produced in the ways already indicated. It may be set down as a rule, that dreams of the present are of graver import as clews to the mind-state than the other classes of dreams on which we must now bestow a few moments' attention.

Dreams of the past and future do not call for detailed consideration, and may be most conveniently noticed together. When the faculty which makes dreams dives deeply among the lumber for its materials, it is either very active, and probably not sufficiently worked in the waking hours, or it has not much interest in recent events, because these have not made a very strong impression on the mind. It often happens that at a period of life when there is not any particularly keen interest in the present, the dreams are of the past. When a man is growing old, he dreams of his early life, not merely because there is in all respects a tendency to revert to the beginnings of life when the power of vitality is on the wane, but because there is a loss of interest in the present. The heat of the struggle is over, and the emotions are no longer as active as they were, so that self-consciousness comes to be increasingly a retrospect of experience. Dreaming only occasionally of the past may be the simple result of the association of ideas, the dream really consisting in a present recollection of records relating to the past: but I am now speaking of the habitual reproduction of long-past and possibly forgotten pictures and records of memory in dreams. Dreams of the future are, for the most part, anticipations arising out of the affairs of the present. They are, properly speaking, forebodings, or eager foretastes, of the dreaded or desired issue of plans and experiences which belong to the present. There is no reason to suppose that the mind is capable of prophesying while the supreme cerebral centers sleep. Most of the so-called dreams of the future are really vaticinations of the imagination while on its way to sleep or slowly emerging from the state of self-forgetfulness.

The inchoate dreams which approximate to paroxysms of delirium constitute the fourth class into which I have divided these experiences.

They are often exceedingly distressing, and bespeak a troubled or disorderly state of mind, but they are not, in themselves, so threatening to mental health as certain varieties of the dream of the present, to which we have already adverted. Dreams consisting of disconnected and fantastical pictures and ideas are commonly of short duration, and occur more frequently in the act of going to sleep than in that of awaking. They may be amusing or annoying; and they are not uncommonly the causes of bad sleep—or, more accurately speaking, of delay in going to sleep. The brain is awakened by the merriment or the disgust occasioned by these dreams. Sometimes the would-be sleeper rouses himself by laughing at the grotesque imagery presented to his mental vision, or the strange ideas which occur to him. The mind may be so disturbed by these awakenings that sleep becomes impossible. Probably the most common cause of this class of dreams is an undue excitement of the organs of sense immediately before going to bed. Such dreams occur after visits to the theatre, reading novels, or hearing music late in the evening. They also frequently follow gay and dissipating scenes or experiences. The sense-organs are overexcited, without being wearied, or so much agitated that they can not rest. Except when they indicate a generally excited brain, dreams of this class are not of great moment, and are easily obviated by giving the mind regular and methodized work, which lowers the excitement and induces moderate fatigue without distressing it. Sufferers from this trouble may generally cure themselves by reading aloud some not very exciting but sufficiently interesting book for half an hour before retiring to rest. The aim should be to give the mind a subject of thought with which it may engage its attention, and shut out the troublesome crowd of imaginings which obtrude the moment the head is laid on the pillow and the eyes are shut.

It follows from these general considerations, that dreams are made out of the pictures and records of thought, that the making of dreams must be, to a much larger extent than we are wont to suppose, under the control of the will. The difficulty of believing this to be the truth lies in the fact that the will is not able to call up or prevent a particular dream or class of dreams. The making of dreams is not an affair of *now*, at any period of life. The material employed in their production is the stock of pictures, impressions, conceptions, and feelings previously accumulated. Meanwhile, he who would dream pleasantly in adult life must see to the material with which he stores his mind in youth; while, in the heyday of manhood, we are heaping together the material of dreams for old age. The mind is not conscious—or does not notice—one half the impressions it receives from its surroundings. To this circumstance, in fact, is due the surprise with which we view, as for the first time, many of the unconsciously received or treasured impressions which are reproduced in dreams, and hence the feeling that they are *original*. It is not, therefore, possible to prevent the

accumulation of pictures and records which we would gladly eliminate from the stock material of dreams; but much may be done to improve the store as a whole by feeding the mind with wholesome and healthy thoughts and impressions. He who makes it a rule through life—beginning early in youth—to take care that what he puts away in his mind and accumulates is, as far as may be possible, a treasure of pure and good materials, will do much toward making the dreams that haunt his sleep in the later years of life not only tolerable, but, so far as night-thoughts can subserve any useful or beneficial purpose, improving. There can be no question that pleasant dreams sometimes afford relief to the mind, especially when they occur on awaking, or when they blot out the disagreeable impressions of the day, and facilitate the process of passing into a state of natural and complete sleep. Such dreams do not last long, and are seldom so intense as to distress the faculties. There is always a danger, in light sleep, of the senses being partially awake to surrounding impressions, and making them the pegs on which to hang a dream. It is, therefore, important to secure the most peaceful and negative conditions for sleep. Dreams are often made by the externals of the sleeper. To avoid this contingency, the sleeper should train his senses to disregard the external when composing himself for sleep. This is not difficult to do if the mind is set resolutely for a few nights in succession to shut out or ignore the impressions that strive to attract it through either or all of the senses. It is happily not required of us to know the way in which we accomplish all the acts we perform; and, in respect to some, it is better not to be too curious concerning the means if we gain the end. In regard to dreams and the making of dreams it will, however, be found an advantage to be fairly well-informed.—*Gentleman's Magazine.*

## SANITARY RELATIONS OF THE SOIL.*

By Dr. MAX VON PETTENKOFER.

II.

WATER plays quite as important a part in the soil as air. Obviously, no organic life, no organic change, can be conceived of without water; and we ourselves consist three parts in four of water. Therefore it may be inferred that change in the moisture of the soil must have a certain influence on its organic and organized constituents, and on the organic life within it. Two degrees of moisture in the soil may be especially distinguished: one in which air and water both

* An address delivered before the Association of German Naturalists and Physicians, at Salzburg, September 18, 1881.

occupy the pores, and one in which the pores are quite filled with water excluding the air. In the former case we may speak of soil-moisture (*Bodenfeuchtigkeit*), in the latter of ground-water (*Grundwasser*). In many cases, but not universally, the transition from soil-moisture to ground-water is very plainly indicated.

The coincidence of the existence of ground-water with the prevalence of typhoid has been a constantly recognized fact since 1856. It was discovered by Buhl, has been tested by Seidel according to the law of probabilities, and has been followed out and confirmed down to the present day by Port for the garrison at Munich, and by Ziemssen for the avenues of the civil hospitals; by whom it is shown that, when the amount of ground-water is above the average, fewer, when it is below the average, more, cases of typhus appear. The same law was discovered by Virchow for the fluctuations of typhus in Berlin. The lowest degree of saturation exists in Berlin during the later summer and the fall, in Munich during the winter, and the seasons of typhus are correspondingly different in the two cities: the latter part of summer and the fall in Berlin, winter in Munich. When the summer is unusually dry at Munich, summer epidemics prevail there also.

That the cause of these conditions is not the ground-water in and of itself, but the moisture in the overlying strata and the processes dependent upon it, is very plainly shown by two facts: first, that some typhus-centers have a porous soil but no ground-water; and, second, that the level of the ground-water may be raised and depressed by artificial means, as by damming, pumping, or draining, without any notable influence being produced upon the prevalence of typhus. The first case occurs in places where on account of the steepness of the descent, or of any other cause, no ground-water collects on the lower impervious strata; the second case, where the level of the ground-water is within the mark of the flood-height of a river. In Munich, for example, it was necessary on one occasion, in order to carry on some excavations in a part of the city near the Isar, to leave a gate in the river open for several months, so that the water sunk more than a metre. No increase of typhus was observed; and when the gate was closed, and the water was allowed to rise again to its original height, the typhus did not diminish. A coincidence with the prevalence of typhus appears only when the variations in the level of the ground-water proceed from the saturation or the drying-up of the strata lying above it. I have always regarded the state of the ground-water only as the best and plainly visible sign or index of the rhythm of the soil-moisture in the overlying strata.

Macpherson, Lewis, and Cunningham have shown beyond a doubt that the cholera fluctuates in its home in India, like abdominal typhus with us, inversely with the annual amount of rain and of saturation of the soil. It behaves in the same way with us. The remarkable division of the cholera into a summer and a winter epidemic, which was

observed in Munich in 1873 and 1874, can be explained only by reference to the conditions of the soil as to moisture. The epidemic began at the end of an abnormally dry July, prevailed with extraordinary violence till the beginning of August, became stationary about two weeks afterward, and seemed wholly to have disappeared at the end of October, only to break out anew with greater violence in November after a long spell of dry weather, and continued till the end of April, 1874. The city of Augsburg, nine miles from Munich, suffered more severely in proportion than that city in 1874, but was quite free from cholera in 1873, notwithstanding many cases were introduced. It had thirty per cent more rain in that year than Munich.

I can not go further into the consideration of these circumstances; I only cite them as evidence of the influence of moisture in the soil so far as it is measurable by the proportion of ground-water present. We are more nearly concerned with the relation of the soil to the water which we apply to our own use, which we draw from wells and springs, to water as a vehicle conveying matters out from the soil. When typhus or cholera rages epidemically in any place, two parties immediately set up a contention as to whether the epidemic influence proceeds from the water or the air. It must be admitted henceforth that either is possible, that a so-called sickly soil can impart its noxious properties equally to the water and to the air it contains, but it may also be that only one of these ways is possible as to certain matters and lower organisms. Observation and experiment must decide upon that. Most physicians have hitherto considered that infection was probably most directly conveyed through the water, and the so-called drinking-water theory has been developed from this view. It has, however, been ascertained that the best known infectious agent in the soil, the *Bacillus malariæ*, which Klebs and Tommasi-Crudelli have discovered and studied in the Roman fever-districts, can not live without air. These investigators found that the malarial poison was not communicated to the water that stood over a richly malarious mud. Tommasi says, in his latest work on the Roman malaria and the ancient drainage of the Roman hills, that "the *Bacillus malariæ* is preeminently an air-living organism." Among the conditions favorable to its propagation in a malarial soil—which need not be a swamp-soil—Tommasi specifies a temperature of about 20° C. (68° Fahr.), a moderate degree of steady moisture, and the direct action of the oxygen of the air on all parts of the mass. He says further, "The lack of one of these conditions is enough to cause a suspension of the development of the spores and of the increase of the malarial ferment." If any one, however, believes that this organism must also remain inoperative when it passes into our blood because that is a fluid, he should be reminded that it makes a great difference whether we put such organisms, taken from their airy nests in a moist soil, into cold water, or into warm blood where air is supplied to them from the corpuscles.

We can not, indeed, answer, with the results of experiment and microscopical investigation, questions respecting the infectious diseases with the specific germs of which we are not acquainted, but we may be guided in the matter by other facts. Naegelli says: "Contagion-fungi can keep up their peculiar activity in water only for a short time. The purer it is the less food they find in it; they are very soon removed by exhaustion in clear spring-water; and, even in water that contains food for them and where they can multiply fast, degeneration quickly sets in, and they are changed into common ferments."

Inasmuch as we are not acquainted with the germs of typhus and cholera except through their infectious operation, we can not, so long as we use at the same time the air and the water of the infected place, decide whether the epidemic germ is imparted to us by the water or by the air. If only one of the elements could be used while the other could be entirely excluded, we might anticipate a time when investigation should bring us to a decision on the subject. Many cases are now known where cholera and typhus have run their course without any part of the local water having been used as drinking-water, but not a single case where the local air was excluded while the local water was used. A severe epidemic of typhus that prevailed in the city of Basle last fall and winter enforced the lesson that not even the purest water, brought from far away in the Jura, could afford protection against those diseases. With this fact the probability, in cases where the epidemic influence can be ascribed to both the air and the water, that it exists in the water, falls to a minimum. We may then ask, Why might not the infection in these cases have been brought out from the soil by the air? It is not my intention to argue here, where discussion is not possible, against the drinking-water theory; I only call attention to the fact that the most convincing proof of it is wanting. My disbelief in it, however, does not prevent my desiring pure and abundant water for all dwelling-places of man, for we need it, not only as a means of protection against typhus and cholera, but for the daily use of sick and well; not only for the sake of cleanliness and for food, but also as a luxury.

The examination of the fungoids has brought out many facts of great hygienic importance, among them some that concern organic life in the soil. I acknowledge the fact gratefully, but can not abstain from indicating a few points which show the necessity of being guarded in practical hygiene against too hasty conclusions. Mycology would assume more than belongs to it, if it should imagine that hygiene was first placed on a scientific foundation or that it first reached a scientific standing when the cultivation of bacteria was begun, or that it had nothing more to do in the future than to look into the microscope and work with the steaming-pot and wadding-stopper. The professional hygienist has still much else to do; but if he keeps himself familiar with the results of the investigation of the germs, then

we may have another hygienist who shall make as beneficial a use of them as the surgeon Lister has made of the investigations of Pasteur and others in his antiseptic bandage. The mycologist did not deduce the ultimate practical results—that belonged to the surgeon ; and on this ground I believe that the hygienist is not yet a superfluous piece of furniture.

The mycologists have told us, for example, that particular solutions and concentrations of the same are essential for certain ferments or certain of their properties, and that they thrive weakly or not at all in fluids otherwise constituted. A fluid may contain all the necessary constituents, but be too diluted or too concentrated. We may consider all putrefaction and decay of suitable substances, the refuse of our households, the waste water with which we irrigate and manure the soil, as affording food-fluids for the lower organisms. Then we might think—and the like has been thought and said—that dirt is not dangerous to health if it is only properly concentrated. It has been asserted that there is much more dirt in the country and in the villages where citizens go—as they say—to get the air, than in the city. A closer investigation would, however, show that there is a real difference between the city and the village, between country life and city life, but not between the consequences of filth in the city and in the country. Cleanly kept houses are healthier than dirty ones, even in the country. The villages, however, are only apparently filthier than the cities. Indeed, the great density of the population of the cities is in itself like a concentration of the filth, and the scattering of the dwellings in the country is like a dilution of it. In the villages the manure-heaps are on top of the ground and open to the air, which, ventilating them freely, effects a salutary dilution and change : in the cities we do not bring the dirt out into the yard, but we deposit it by the walls of our houses ; we do not let the free atmosphere work upon it, but try to keep it away from the air as much as possible by inclosing it in pits which are well covered and arched over, but are connected with the house by invisible pipes and canals. We let nothing escape into the free air, but believe that we need not regard what reaches the ground under the house and the air within the house. In the cities we insist very much on outward cleanliness, that the dirt must not be exposed, and cover it up beautifully in our houses and yards, so as to make the impression that there is none, as a dirty skin and foul linen may be covered by handsome outer garments.

Admitting that there may be a kind or amount of concentration of filth in the soil that will prevent the growth of certain ferments, as the development of fermenting bacteria and fungoids is prevented in fruits by seething them in concentrated sirups, hygiene has yet to ascertain how highly concentrated filth in the soil must be to prevent the ferments in it that contribute to cholera and typhus from being effective. It should also be borne in mind that even if a sufficiently

high degree were reached at any place on the premises, as, for example, in a cesspool, that concentration would cease and a favorable degree of dilution would take its place, somewhere in the neighborhood, at a greater or less distance from the focus of filth. We should therefore always insist upon the degree of cleanliness which we understand to promote the greatest possible prevention and dilution of filth, as our hygienic aim ; and we shall furthermore do well, if we remove not only from our houses, but from the neighborhood, and keep removed, all that seems to us to be dirt, and offends our innate æsthetic feelings.

The mycologists have further taught us that no germs escape from fluids and moist objects by mere evaporation, but that they only pass into the air in the form of dust, or when gases are generated and puff out, or when something adheres to things that are washed with such moist objects. We might be tempted to conclude from this that nothing more is necessary, to make and keep our abodes free from disease, than to keep everything properly moist. But, aside from the fact that damp houses and damp soils are positively disadvantageous to health, it would not be possible to maintain such a degree of moisture or other conditions that it should never be too dry, that there should never be any spurts of gas, and that no germs should ever be washed off. We can judge of the uselessness of such efforts from the fact that no one has ever found air, either out-of-doors when it has rained incessantly for a long time, nor in a house where it is still moist, that was free from mold. We attach more importance to the fact, likewise established by mycologists, that all germs flourish only in fluids and damp media, and that moist walls, not dry ones, become moldy.

If moisture really afforded protection against the escape of germs, we might imagine the drains and sink-holes connected with our houses to furnish the best kind of drainage, because they are always moist, and contribute something to the required moisture in the soil. I consider these sinks close to the house to be dangerous neighbors, even when they are designed only to carry off rain-water. I proceed upon the time-honored experience of physicians that certain malarious diseases prevail most actively in damp spots in houses and villages situated in hollow places or at the foot of slopes, after inundations. A sink is an artificial trough, an artificial flood-region for each house, into which is concentrated the drainage from the roof and from the surrounding ground. By it a certain part of the house-ground is exposed to occasional floods, which can have no other results for the house than the occasional inundations in a larger region have for the places lying within it. When such pits are unavoidable, it is well to have them as far as possible from the house ; but it would be better to conduct the water coming from the roof or elsewhere to some place where it can no longer prejudice our health. I look upon the removal or great diminution of these sinks as constituting the chief advantage of the sewerage of cities. The hygienic value of sewerage may have been

sometimes exaggerated—there was a time when many believed that it would remove all sickness, and it would not be surprising if the reaction against this exaggeration should lead to an undue depreciation—but it is an established fact that every city that has completed a well-flushed system of sewerage in connection with house-drainage has gained in health, and that its death-rate, especially from diseases connected with the soil, has diminished. I mention the reports, on the frequency of typhus before and after sewerage, of John Simon for the English cities, of Varrentrapp for Frankfort-on-the-Main, and of Lievin for Dantzic. We hear, indeed, that the general prevalence of typhus has ceased, and that its disappearance in these cities is wrongly placed to the credit of costly sanitary works; but the coincidence must be full of significance to every unprejudiced person that the disappearance of typhus in different cities has not taken place simultaneously and in the same degree, but has generally begun with the introduction of water-works and sewers. In Hamburg, for instance, improvement began to be evident in 1848, and in Dantzic in 1872. If now we conclude that the *genius epidemicus* has undergone a change, this genius must have manifested a wicked partiality for Hamburg and a devilish maliciousness toward Dantzic, to have kept the latter city so long in his claws. Soyka recently communicated to the meeting of the German Sanitary Union a statistical report respecting the typhus in Munich, in which the influence of sewerage was set forth in the plainest manner, perhaps more plainly than it has been done in any other case. It is known by long experience in this city that abdominal typhus, when it is epidemic, prefers certain quarters, including sewered and unsewered parts alike, and that it spares certain quarters, including sewered and unsewered parts alike; showing that the disease is generally connected with the local situation, not with the existence or non-existence of sewers. Now, Soyka has found that between 1866 and 1880 typhus diminished in the unsewered and the old and badly sewered parts of the city, in round numbers, only ten per cent, in the favorably situated and well-sewered parts about twenty per cent, in the unfavorably situated but well-sewered parts about forty per cent. That the wonderful result in the last case was accomplished by sewerage becomes obvious when it is considered that in it an otherwise fertile typhus-field, in which more seed was to be destroyed, had to be dealt with. Such facts make it very hard for the opponents of sewerage to continue to deny its hygienic advantages.

A well-regulated system of sewerage with adequate flushing not only promotes the removal of much filth, but also effects a great dilution of all soluble and floating dirt, and contributes toward rendering it harmless and effecting its complete destruction. The opponents of sewerage insist that it is impossible to construct a perfectly tight system of sewers. This is not essential; it is enough to reduce the quantity of impurities penetrating into the soil, so far as they are of

an organic nature, to so low a degree that they shall be quickly changed and rendered harmless by the soil. The ground has a certain power to purify itself.

Falck made the discovery not long ago that water containing infectious matter, formed and unformed ferments, organic poisons, etc., ran off pure after having been filtered through very thin beds of sand. At first, the ground only absorbs, as, for example, finely pulverized coal removes matters from fluids; but Soyka has found that under conditions of sufficient dilution and exposure to air a real destruction of the absorbed organic matter also takes place, so that even substances that are otherwise unchangeable, as, for instance, strychnine, are as completely destroyed by it as if they had been burned in the fire. This explains why the soils of many places that have been inhabited from the earliest times so frequently look to the naked eye, when they are dug over, like virgin soils. Traces of impurity are visible only in places where more is demanded of the ground than it can perform. It is therefore not surprising that the ground under the sewers of Hamburg does not appear to have been contaminated to any great extent. Wolffhügel's investigations, on the other hand, show that the ground under cesspools and drains, in which filth accumulates in a more concentrated form than in flushed sewers, presents a very different appearance. Professor Hofmann's most recent investigations in the soil of the streets of Leipsic show that the ground under the bottom of even badly built sewers is much cleaner than that over their tops or that under the pavements.

Very instructive are the researches of Emmerich, showing that various kinds of foul water, which are sure to kill when injected under the skin of rabbits, become harmless as soon as they are shaken up with common sand, or if they are diluted with a certain proportion of pure water.

Every foul soil which we cease to pollute purifies itself again in the course of time, and every clean soil, to which no more impurity is introduced than it can work up, remains clean. It is certainly interesting that this purification of the ground is dependent for the most part on the activity of the lowest organisms, as has been proved with reference to the conversion of nitrogenous organic matters in the ground into nitric salts, or to what is called nitrification, by the researches of Schlösing and Müntz. We know as little of the nitrifying germ in the ground as we do of the cholera and typhus germs, but we can and must judge of it by its works. We learn from its operations that the representatives of the lowest organic life, of the cell-life, perform not merely injurious but also very useful functions, that they are not merely noxious or poisonous plants; and we need not be surprised if a later age, when more has been learned in these matters than is now known, shall cultivate the useful bacteria, and make war only upon the injurious ones.

As there are soils which are more easily nitrified than others, so there are those which more readily bring forth disease than others; and it is the duty of hygiene to search further into the biological processes going on in the ground. We are still very far from the end: a boundless sea of probabilities lies before us; but that need not prevent our weighing anchor and spreading sail.

Hitherto we have allowed ourselves to be guided in hygienic practice and technics predominantly by the feelings, instincts, and what we call common sense, and have only very recently begun to establish our practice, which is, indeed, very primitive, on a scientific and experimental footing. Dirt and impurity have till now been somewhat indefinite conceptions. We use the terms whenever our innate or cultivated sense of cleanliness is unpleasantly affected; they are generally called out by impressions on our sense of smell, taste, or sight. What we call cleanliness plays an important part in daily life, in a similar manner to that which conscience, the sense of right and wrong, partly innate, partly inculcated, plays in our moral life. Just as it can be regarded as a fact that conscientious men as a rule accomplish more and better than unconscientious, so cleanly men as a rule are healthier and live longer than uncleanly men. As conscience is more or less developed in different degrees of human civilization, so also is the sense of cleanliness. Under the guidance of analogous feelings, we have instinctively and empirically found out what it is to our advantage to eat and drink, and how we should clothe ourselves, before these subjects could be dealt with scientifically.

Our established hygiene also was probably based in the first instance chiefly on the suggestions of feeling. Those who are moving in the new scientific direction should guard against considering all that is not scientifically confirmed as wrong and unfounded, but they should also not hesitate to subject established rules to a thorough scientific and experimental criticism. This will necessarily teach us that mere feeling has dictated much to us that rests upon false suppositions, and can either be omitted or must be changed. Practice or technics always precedes science. Our branches of trade and industry also began on empiric roads, and were carried on in them for thousands of years; but how greatly have they been changed, improved, and simplified, and how many new branches have arisen since we began to apply the sciences of physics, chemistry, and mechanics to them!

Hygiene, or the science of health, has a widely extended field of labor in laying a scientific foundation for our sanitary regimen. Even if in many cases it only shows that all is not as it has heretofore been supposed to be, that has its great practical value. What harm did it do to medical practice that the Vienna medical school in its day showed up the errors of the then prevailing views, and radically assailed the practice founded upon them which had been adopted for

centuries? An analogous example in contemporary hygiene was afforded at the meeting of the German Public Health Association, when Hofmann and Siegel showed by the light of experimental researches and exact observations that our church-yards and burial-grounds, provided the soil is in a proper condition, and a proper, easily applied restorative treatment is adopted, are not so detrimental to the ground-water and air, and consequently to the health of persons living near them, as has been heretofore believed, but that the water from wells inside of the church-yards is generally purer than that in the inhabited places around them, so that in this respect we have more to fear from the living than from the dead. We are injured by our method of burial quite as little as we were injured when systematic blood-letting in inflammatory diseases was abandoned in consequence of the observations of Skoda and Rokitansky.

It will not be otherwise with hygienic practice than it has been with therapeutics, if we now begin to apply a scientific method to it. May the medical faculties and the government speedily grant means to do it! The most beneficial practical results will not fail to be realized.

## LONGEVITY OF THE OYSTER.

By Professor SAMUEL LOCKWOOD.

IT is proposed to give an account of an interesting determination of the extreme age of a pair of venerable oysters which have just come into my possession. They were given me by a professional oyster-grower, Captain T. S. R. Brown, of Keyport, New Jersey, and belong to a planting in which he was concerned thirty years ago. The young oysters were obtained from Virginia, and planted in Raritan Bay, Keyport. At the proper time the crop was taken up and sent to market. In all such cases there are leavings or escapes from the dredging. The bottom being too hard, the bed was abandoned and never planted again, and these oysters were found there a few days ago. They are not "naturals" or natives, but simply naturalized "Virginies," a distinction which a practical oyster-raiser will make unerringly. Any one examining the shells would infer the nature of the bed whence they were taken, for the outer edges of the "shoots" or layers are smooth, as if worn by a gentle motion on a compact sandy bottom. The shells are large, though not larger than or even as large as many often seen in market; but the latter, if "primes," have been of much quicker growth, and the mollusk is larger and finer. In a word, they are many years younger than the pair I am considering, and were grown on a softer bed, and one which was for them in every way a richer feeding-ground. The two oysters in question measure,

one seven inches long and three and a half wide, the other seven and a half inches long and four inches wide. The shells are quite heavy, and for their size the oysters are not so large as might be inferred; but they were eaten, and the verdict was that one was good and the other fair. As this was the judgment of an oyster-raiser, it had special value. The age of an oyster may be reckoned by counting the lines in the depression or groove of the hinge of the bivalve. These lines truly indicate the layers or annual shell-growths, being really the anterior extremity of the annual shell deposits. But the lower shell of an oyster, that is, the valve in which the animal lies when the shell is in normal position, is the deeper and heavier of the two, and, as its annual shell-layers correspond in number with those of the upper valve, it follows that they must be proportionally thicker. Hence the result is that the hinge-groove of the lower valve is longer than that of the upper valve, because the lines which are the extreme edges of the layers are thicker than the lines in the upper groove. Wherever the oyster has room and fair conditions this is the necessary law of its growth, viz., for gravity's sake the ponderosity is given to the lower valve; also for the comfort and growth of the animal, as it secures it a normal position and the proper trough or cradle in which the mollusk can grow. When oysters are excessively crowded they will grow standing on end, that is, side by side, with the nib or wide end uppermost, thus producing those worthless, elongated forms known in some localities as "strap-oysters" and "stick-ups."

Being interested in these specimens as uniques, to me at least, I was concerned to see if the natural record would tally with the well-authenticated tradition of their age. To shorten the story, I will give the method of examination of but one of them. In this instance the distal end, that is, the oldest parts of the hinge-grooves, were coated with the skeletons of bryozoa, hence the line-record was partly obliterated, so that a clear count could only be got from the near end of the groove. Fortunately, the lines were so uniform in thickness that the estimation was reduced to a simple question of proportion. By actual measurement the length of the upper groove was one and a half inch, and that of the lower one was two and a half inches. Now, in the upper groove there were five of these annual layer-lines in a quarter of an inch, and in the lower groove there were, as nearly as I could make out, three lines and a third of a line in a quarter of an inch, which would give thirty of these annual lines for the upper groove and thirty in the lower groove, all which would tally with the tradition that the bivalve was thirty years old.

Two points are established by the above: first, the great longevity of the oyster; the specimens were in excellent condition, and there was nothing about them to disprove the belief that, if allowed to lie undisturbed, they might have lived and grown ten years longer; and second, that an oyster may be good and palatable food at a great

age. I have seen old oysters obtained from newly discovered and crowded beds that as food were literally worthless; but the specimens discussed were not found in such conditions.

It is fortunate for science when some intelligent man like Captain Brown puts the student in the way of a fact so interesting; and that interest grows into an intense enjoyment when the tradition is ratified by a reading of Nature's own writing. I remember the case of an oyster-grower at Keyport, who noticed that a fine "prime" oyster was spoiled for market because the dredge had broken a piece, measuring three quarters of an inch, off the nib, so that the mollusk itself was exposed. This was in October. He took the broken oyster and put it in the water by the side of a pile. Next summer he examined it, and found that the animal had completely repaired his house, thus establishing two important facts—the great damage which the mollusk can repair, and the time needed for the reparation.

## A GLIMPSE THROUGH THE CORRIDORS OF TIME.*

By ROBERT S. BALL, LL. D., F. R. S.,

ANDREWS PROFESSOR OF ASTRONOMY IN THE UNIVERSITY OF DUBLIN, AND ROYAL ASTRONOMER OF IRELAND.

YOUR committee has done me much honor by inviting me to deliver the first lecture in this large and very beautiful hall. In accepting the task I was aware that it involved a great responsibility, but I had various grounds of encouragement. I remembered that I was not coming among you as a stranger, and I knew that I had a subject worthy of a memorable occasion. I would I were equally confident of my ability to do justice to so noble a theme.

The lecture bears the somewhat poetic title of "A Glimpse through the Corridors of Time." A poetic title has been chosen, because, if I can properly exhibit the subject, you will see that it appeals powerfully to the imagination as well as to the reason. I shall invite you to use your imagination to aid in looking back into the very remotest recesses of antiquity. And when I speak of antiquity I do not mean the paltry centuries with which our historians have to deal. The ancient days to which I refer are vastly anterior to those of the "grand old masters" and those of the "bards sublime." Nor do we even allude to the thousands of years which have elapsed since Babylon and Nineveh were splendid and populous cities. Even the noble pyramids of Egypt are but of yesterday when compared with the æons of years which must pass before our review.

The most ancient human monuments that now exist can not, I sup-

* Lecture delivered at the Midland Institute, Birmingham, October 24, 1881.

pose, be more than a few thousand years old. Five thousand years nearly exhausts all historical time. Ten thousand years certainly does. Though we have no earlier historical record, yet other records are not wanting. Geology tells us that ten thousand years is but a mere moment in the span of the earth's history. We learn from geology that even the career of man himself has lasted far more than ten thousand years. Yet man is but the latest addition to the succession of life on the earth. For the chronology of the earlier epochs of the earth's history we require majestic units to give adequate expression to our dates. Thousands of years are not sufficient, nor tens of thousands, nor hundreds of thousands. The course of geological time is to be reckoned in millions of years.

The corridors of time through which I wish to give you a glimpse are these dignified millions. Yet our retrospect will only extend to a certain definite epoch in the past history of our earth. We speak of nothing anterior to the time when our earth assumed the dignity of maternity, and brought forth its first and only child. We shall trace the development of that child which, though millions of years old, is still in dependence on its parent. We shall describe the influence of the parent over the child, and the not less remarkable reaction of the child upon the parent. We shall foreshadow the destiny which still awaits the mother and child when millions of years shall have elapsed.

At the time of its birth the earth was not, as we see it now, clothed with vegetation and teeming with animal life. It was a huge inorganic mass, too hot for life, perhaps hot enough to be soft or viscid, if not actually molten. The offspring was what might be expected from such a parent. It was also a rude inorganic mass. Time has wrought wondrous changes in both parent and child. Time has transformed the earth into an abode of organic life. It has transformed the earth's offspring into our silvery moon.

It will be my duty to sketch for you the manner in which these changes have been brought about. To a great extent we can do this with no hesitating steps; we are guided by a light which can not deceive. It is the light of mathematical reasoning. These discoveries are of an astronomical character, but they have not been made by telescopes. They have been made by diligent labors of the most abstruse kind. The mathematical astronomer sits at his desk, and not in an observatory. He has in his hand a pen, and not a telescope. Before him lies a sheet of paper, and not the starry heavens. He is no doubt furnished with a few facts from observation. It is his province to interpret those facts, to inform them with life, and to infer the unknown from the known. It is thus discoveries are made which are the sublimest efforts of human genius.

The argument on which I invite you to follow me is founded on a very simple matter. Many of those present go every summer to the sea-side. Those who do so are well acquainted with the daily ebb and

flow which we call the tides. Even the children with their spades and buckets know how the flowing tide will fill their moats dug in the sand and inundate their mimic castles. In the ebb and flow of the tide we have a mechanical engine of mighty power. I hope this evening to point out the wonderful effect which tides have had on the earth in times past, as well as the effect they will exercise in the future. It is the tides which are to reveal to us a glimpse through the corridors of time.

The cause of the ebb and flow of the tide has long ceased to be a mystery. In the earliest times it was noticed that the tides were connected with the moon. Pliny and Aristotle both refer to the alliance between the tides and the age of the moon. It is well known that the tides on our coasts sometimes rise to an unusual height. Those who dwell on low ground adjoining tidal rivers are painfully aware of this fact by the floods which are often produced. Such occurrences generally take place at the time of new moon or of full moon. At first quarter or last quarter the tides are even below the usual height. A fisherman who has to regulate his movements by the tides will know full well that at certain times the tides rise higher and fall lower than at other times. He brings his boat out on the falling tide, he brings it back on the rising tide, and, when making the harbor after a night's fishing, it would be natural to hear him say, "Oh, we shall run in easily this morning, there is a strong tide, the moon was full last night." Or if he had to cross a dangerous bank he would soon learn the difference between the spring tide and the neap. Fishermen are not much addicted to abstract reasoning. For many centuries, perhaps indeed for thousands of years, observant men might have known that the moon and the tides were connected. But they did not know any reason why this connection should exist. I dare say they did not even know whether the moon was the cause of the tides or the tides the cause of the moon.

Nor is it easy to explain the tides. We were all taught that the moon makes the tides. Yet I can imagine an objector to say, If the moon makes the tides, why does it give Bristol a splendid tide of forty feet, while London is put off with only eighteen? The true answer is, that the height of the tide is largely affected by local circumstances, by the outline of the coasts, by estuaries and channels. It is even affected to some extent by the wind. Into such details, however, I do not now enter: all I require is, that you shall admit that the moon causes the tides, and that the tides cause currents. In some few places the currents caused by the tides are made to do useful work. A large reservoir is filled by the rising tide, and as the water enters it turns a water-wheel. On the ebbing tide the water flows out of the reservoir, and again gives motion to a water-wheel. There is here a source of power, but it is only in very exceptional circumstances that such a contrivance can be worked economically. Sir W. Thomson, in his ad-

dress to Section A of the British Association at York, went into this question in its commercial aspect. At present, however, we may say that the power of the tides is as much wasted as is the power of Niagara. Perhaps, when coal becomes more scarce and when the means of distributing power by electricity are more developed, the tides and the great water-falls will be utilized; but that day will not be reached while coal is only a few shillings a ton.

Though we have not yet put the tides into harness, yet tides are not idle. Work they will do, whether useful or not. In some places the tidal currents are scouring out river-channels; in others they are moving sand-banks. From a scientific point of view the work done by the tides is of unspeakable importance. To realize the importance, let us ask the question, Whence is this energy derived with which the tides do their work? The answer seems a very obvious one. If the tides are caused by the moon, the energy they possess must also be derived from the moon. This looks plain enough, but unfortunately it is not true. Would it be true to assert that the finger of the rifleman which pulls the trigger supplies the energy with which the rifle-bullet is animated? Of course it would not. The energy is derived from the explosion of the gunpowder, and the pulling of the trigger is merely the means by which that energy is liberated. In a somewhat similar manner the tidal wave produced by the moon is the means whereby a part of the energy stored in the earth is compelled to expend itself in work. I do not say this is an obvious result. Indeed, it depends upon a refined dynamical theorem, which it would be impossible to enter into here.

But what do we mean by taking energy from the earth? Let me illustrate this by a comparison between the earth rotating on its axis and the fly-wheel of an engine. The fly-wheel is a sort of reservoir, into which the engine pours its power at each stroke of the piston. The various machines in the mill merely draw off the power from the store accumulated in the fly-wheel. The earth is like a gigantic fly-wheel detached from the engine, though still connected with the machines in the mill. In that mighty fly-wheel a stupendous quantity of energy is stored up, and a stupendous quantity of energy would be given out before that fly-wheel would come to rest. The earth's rotation is the reservoir whence the tides draw the energy they require for doing work. Hence it is that, though the tides are caused by the moon, yet whenever they require energy they draw on the supply ready to hand in the rotation of the earth.

The earth differs from the fly-wheel of the engine in a very important point. As the energy is withdrawn from the fly-wheel by the machines in the mill, so it is restored thereto by the power of the steam-engine, and the fly runs uniformly. But the earth is merely the fly-wheel without the engine. When the work done by the tides withdraws energy from the earth, that energy is never restored. It

therefore follows that the energy of the earth's rotation must be decreasing. This leads to a consequence of the most wonderful importance. It tells us that the speed with which the earth rotates on its axis is diminishing. We can state the result in a manner which has the merits of simplicity and brevity:

"The tides are increasing the length of the day."

This statement is the text of the discourse which I am to give you this evening. From this simple fact the new and wondrous theory of tidal evolution is deduced. A great scientific theory is generally the outcome of many minds. To a certain extent this is true of the theory of tidal evolution. It was Professor Helmholtz who first appealed to what tides had already done on the moon. It was Professor Purser who took an important step in the analytical theory. It was Sir William Thomson's mathematical genius which laid the broad and deep foundations of the fabric. These are the pioneers in this splendid research. But they were only the pioneers. The great theory itself is chiefly the work of one man. You are all familiar with the name he bears. The discoverer of tidal evolution is Mr. G. H. Darwin, Fellow of Trinity College, Cambridge.

It would be impracticable for me now to go into the actual mathematical calculations. I shall rather endeavor to give you an outline of this theory, shorn of its technical symbols. I think this can be done, even though we attempt to retain the accuracy of mathematical language. Nor would it be fair to throw on Mr. Darwin or the other mathematicians I have named the responsibility for all I am going to say. I must be myself responsible for the way in which those theories are set forth, as well as for some of the deductions made from them.

At present, no doubt, the effect of the tides in changing the length of the day is very small. A day now is not appreciably longer than a day a hundred years ago. Even in a thousand years the change in the length of the day is only a fraction of a second. But the importance arises from the fact that the change, slow though it is, lies always in one direction. The day is continually increasing. In millions of years the accumulated effect becomes not only appreciable but even of startling magnitude.

The change in the length of the day must involve a corresponding change in the motion of the moon. This is by no means obvious. It depends upon an elaborate mathematical theorem. I can not attempt to prove this for you, but I think I can state the result so that it can be understood without the proof. If the moon acts on the earth and retards the rotation of the earth, so, conversely, does the earth react upon the moon. The earth is tormented by the moon, so it strives to drive away its persecutor. At present the moon revolves round the earth at a distance of about 240,000 miles. The reaction of the earth tends to increase that distance, and to force the moon to revolve in an orbit which is continually getting larger and larger.

Here, then, we have two remarkable consequences of the tides which are inseparably connected. Remember, also, that we are not enunciating any mere speculative doctrine. These results are the inevitable consequences of the tides. If the earth had no seas or oceans, no lakes or rivers; if it were an absolutely rigid solid throughout its entire mass—then these changes could not take place. The length of the day would never alter, and the distance of the moon would only fluctuate between narrow limits.

As thousands of years roll on, the length of the day increases second by second, and the distance of the moon increases mile by mile. These changes are never reversed. It is the old story of the perpetual dropping. As the perpetual dropping wears away the stone, so the perpetual action of the tides has sculptured out the earth and moon. Still, the action of the tides continues. To-day is longer than yesterday; yesterday is longer than the day before. A million years ago the day probably contained some minutes less than our present day of twenty-four hours. Our retrospect does not halt here; we at once project our view back to an incredibly remote epoch which was a crisis in the history of our system.

Let me say at once that there is great uncertainty about the date of that crisis. It must have been at least 50,000,000 years ago. It may have been very much earlier. This crisis was the interesting occasion when the moon was born. I wish I could chronicle the event with perfect accuracy, but I can not be sure of anything except that it was more than 50,000,000 years ago.

I do not admit that there is anything discreditable about this uncertainty. Do you not know that our historians, who have records and monuments to help them, are often in great confusion about dates? I am not going to find any fault with historians. They do their best to learn the truth; but I can not help reminding you that they are often as much in the dark about centuries as the astronomers are about millions. Take, for example, the siege of Troy, which Homer has immortalized, and ask the historians to state the date of that event. Some say that the siege of Troy was 1184 B. C., others that it was 900 B. C.; both are equally uncertain. Schliemann says that he found the remains of the town burned down, but that no one knows who did it or when it was done. Others, again, say that there was never any siege of Troy at all.

A recent instance which has attracted great and deserved attention is Schliemann's discovery at Mycenæ of what he considers to have been the tomb of Agamemnon. The tomb certainly did contain the remains of some mighty man, if we may judge by the hundred-pound weight of gold ornaments which were found there. Most people think that these tombs, whosesoever they were, date from at least 1000 B. C. On the other hand, some very high authorities regard the monuments as the tombs of northern invaders who came into Greece 500–600 A. D.

Here, then, we have a range of some 1,500 years for the date of the tombs, and no dates between these two are possible. I am sure I do not pretend to decide between them, or even to have an opinion on the subject; but I can not help saying that in one respect the astronomers are better off than the historians. The historians can not even agree whether Schliemann's gold ornaments are B. C. or A. D. Astronomers are, at all events, certain that the date of the moon's birth was before the present era.

At the critical epoch to which our retrospect extends, the length of the day was only a very few hours. I can not tell you exactly how many hours. It seems, however, to have been more than two and less than four. If we call it three hours we shall not be far from the truth. Perhaps you may think that, if we looked back to a still earlier epoch, the day would become still less and finally disappear altogether! This is, however, not the case. The day can never have been much less than three hours in the present order of things. Everybody knows that the earth is not a sphere, but that there is a protuberance at the equator, so that, as our school-books tell us, the earth is shaped like an orange. It is well known that this protuberance is due to the rotation of the earth on its axis, by which the equatorial parts bulge out by centrifugal force. The quicker the earth rotates the greater is the protuberance. If, however, the rate of rotation exceeds a certain limit, the equatorial portions of the earth could no longer cling together. The attraction which unites them would be overcome by centrifugal force, and a general break-up would occur. It can be shown that the rotation of the earth when on the point of rupture corresponds to a length of the day somewhere about the critical value of three hours, which we have already adopted. It is therefore impossible for us to suppose a day much shorter than three hours. What occurred prior to this I do not here discuss.

Let us leave the earth for a few minutes, and examine the past history of the moon. We have seen that the moon revolves around the earth in an ever-widening orbit, and consequently the moon must in ancient times have been nearer the earth than it is now. No doubt the change is slow. There is not much difference between the orbit of the moon a thousand years ago and the orbit in which the moon is now moving.

But when we rise to millions of years the difference becomes very appreciable. Thirty or forty millions of years ago the moon was much closer to the earth than it is at present; very possibly the moon was then only half its present distance. We must, however, look still earlier, to a certain epoch not less than fifty millions of years ago. At that epoch the moon must have been so close to the earth that the two bodies were almost touching. I dare say this striking result will come upon many with surprise when they hear it for the first time. It was, I know, with great surprise that I myself read of it not many

months ago. But the evidence is unimpeachable, and it is, indeed, wonderful to see how such information has been gained by merely looking at the ripples of the tide.

Everybody knows that the moon revolves now around the earth in a period of twenty-seven days. The period depends upon the distance between the earth and the moon. The time and the distance are connected together by one of Kepler's celebrated laws, so that, as the distance shortens, so must the time of revolution shorten. In earlier times the month must have been shorter than our present month. Some millions of years ago the moon completed its journey in a week instead of taking twenty-eight days as at present. Looking back earlier still, we find the month has dwindled down to a day, then down to a few hours, until, at that wondrous epoch when the moon was almost touching the earth, the moon spun round the earth once every three hours.

It would require the combined powers of a poet and a mathematician to portray the scene with becoming dignity. I have only promised to give you that glimpse along the Corridors of Time which I have myself been able to obtain. The scene is laid in the abyss of space; the time is more than 50,000,000 years ago; the *dramatis personæ* are the earth and the moon.

In those ancient times I see our earth to be a noble globe, as it is at present. Yet it is not partly covered with oceans and partly clothed with verdure. The primeval earth seems rather a fiery and half-molten mass, where no organic life can dwell. Instead of the atmosphere which we now have I see a dense mass of vapors, in which perhaps all the oceans of the earth are suspended as clouds. I see that the sun still rises and sets to give the succession of day and of night, but the day and the night together only amount to three hours instead of twenty-four. Almost touching the chaotic mass of the earth is another much smaller and equally chaotic body. Around the earth I see this small body rapidly rotating. The two revolve together as if they were bound by invisible bands. This smaller body is the moon. Such is the picture which I wish to present to you as a glimpse through the Corridors of Time.

I have hitherto refrained from introducing any merely speculative matters. If we can believe anything of mathematics, anything of dynamics, we must admit that the picture I have attempted to outline is a faithful portrait. The only uncertain elements are the date and the periodic time. I do, however, now propose to venture on one speculation in which Mr. Darwin has indulged. I propose to offer a suggestion as to how a small body came into this most remarkable position close by the earth, and how its motion was produced.

We have hitherto been guided by the unerring light of dynamics, but at this momentous epoch dynamics deserts us, and we have only probability to guide our faltering steps. One hint, however, dynam-

ics does give. It reminds us that a rotation once in three hours is very close to the quickest rotation which the earth could have without falling to pieces. As the earth was thus predisposed to rupture, it is of extreme interest to observe that a cause tending to precipitate such a rupture was then ready to hand. It seems not unlikely that we are indebted to the sun as the occasion by which the moon was fractured off from the earth and assumed the dignity of an independent body. It must be remembered that the sun produces tides in the earth as well as the moon, but the solar tides are so small compared with the lunar tides that we have hitherto been enabled to neglect them. There could, however, have been no lunar tides before the moon existed, and consequently in the early ages before the moon was detached the earth was disturbed by the solar tides, and by the solar tides alone.

The primeval earth thus rose and fell under the tidal action of the sun. Probably there were no oceans then on the earth; but tides do not require oceans, or even water, for their operation. The primitive tides were manifested as throbs in the actual body of the earth itself, which was then in a more or less fluid condition. Even at this moment bodily tides are disturbing the solid earth beneath our feet; but these tides are now so small as to be imperceptible when compared with the oceanic tides.

At the remote epoch of which we are speaking the solar tides were very small, as they are at present. Yet, small as they are, there was a particular circumstance which may have enormously increased their importance. The point to which I refer can be illustrated very simply. We have here a weight of fourteen pounds freely suspended, and here I have a small wooden mallet which barely weighs half an ounce, yet, small as this mallet is, I can make the heavy weight swing by merely giving it blows with the mallet. Let me try. I give the weight blow after blow. I hit it as hard as I can, yet the weight hardly swings. I have not yet been successful. The art of succeeding is merely to time the blows properly; this I am now doing, and you see the weight swings in an arc which is steadily augmenting.

We therefore see that a succession of impulses, in themselves small, can yet produce a great effect when they are properly timed. In the present case the impulses should succeed each other at the same interval as this pendulum requires for one to-and-fro oscillation. The time therefore depends on the body struck, and not at all on the body which gives the impulses.

Just as this pendulum swings with a definite period, so the vibrations of the primeval earth had a certain period appropriate to them. Suppose that the liquid primeval globe were pressed in on two quadrants and drawn out on the two others, and that the pressures were then released. The globe would attempt to regain its original form, but this it could not do at once, any more than the pendulum can at once regain its vertical position; the protruded portions would go in,

but they would overshoot the mark, and the globe would thus oscillate to and fro. Now, it has been shown that the period of such oscillations in our primitive globe is about an hour and a half, or very close to half the supposed length of the day at that time. The solar tides, however, also have a period half the length of the day. Here, then, we have a case precisely analogous to the fourteen-pound weight I have just experimented on. We have a succession of small impulses given which are timed to harmonize with the natural vibrations. Just as the small-timed impulses raised a large vibration in the weight, so the small solar tides on the earth threw the earth into a large vibration. At first these vibrations were small, but at each succeeding impulse the amplitude was augmented until at length the cohesion of the molten matter could no longer resist: a separation took place: one portion consolidated to form our present earth; the other portion consolidated to form the moon.

There is no doubt whatever that the moon was once quite close to the earth; but we have to speculate as to what brought the moon into that position. I have given you what I believe to be the most reasonable explanation, and I commend it to your attention. There are difficulties about it, no doubt: let me glance at one of them.

I can easily imagine an objector to say: "If the moon were merely a fragment torn off, how can we conceive that it should have that beautiful globular form which we now see? Ought not the moon to have rugged corners and an irregular shape? and ought not the earth to show a frightful scar at the spot where so large a portion of its mass was rent off?"

You must remember that in those early times the earth was not the rigid, solid mass on which we now stand. The earth was then so hot as to be partially soft, if not actually molten. If, then, a fragment were detached from the earth, that fragment would be a soft yielding mass. Not for long would that fragment retain an irregular form; the mutual attraction of the particles would draw the mass together. By the same gentle ministrations the wound on the earth would soon be healed. In the lapse of time the earth would become as whole as ever, and at last it would not retain even a scar to testify to the mighty catastrophe.

I am quite sure that, in so large and so cultivated an audience as that which I am now addressing, there are many persons who take a deep interest in the great science of geology. I believe, however, that the geologist who has studied all the text-books in existence might still be unacquainted with the very modern researches which I am attempting to set forth. Yet it seems to me that the geologists must quickly take heed of these researches. They have the most startling and important bearing on the prevailing creeds in geology. One of the principal creeds they absolutely demolish.

I suppose the most-read book that has ever been written on geology

is Sir Charles Lyell's "Principles." The feature which characterizes Lyell's work is expressed in the title of the book, "Modern Changes of the Earth and its Inhabitants considered as illustrative of Geology." Lyell shows how the changes now going on in the earth have in course of time produced great effects. He points out triumphantly that there is no need of supposing mighty deluges and frightful earthquakes to account for the main facts of geology.

Lyell attempts to show that the present action of winds and storms, of rains and rivers, of ice and snow, of waves and tides, will account for the formation of strata, and that the gentle oscillations of the earth's crust will explain the varying distribution of land and water. In this we can to a great extent follow him. I am quite satisfied with the oscillations in the land. If the land rises an inch or two every century in one place and falls to the same extent elsewhere, all that is required has been explained. Nor do I feel at present disposed to question his views as to rivers or to glaciers, to rains or to winds. There is, however, one great natural agent of which Lyell does not take adequate account. He does not attach enough importance to the tides. No doubt he admits that the tides do some geological work. He even thinks they can do a great deal of work. The sea batters the cliffs on the coasts, and wears them into sand and pebbles. The glaciers grind down the mountains, the rains and frosts wear the land into mud, and rivers carry that mud into the sea. In the calm depths of ocean this mud subsides to the bottom; it becomes consolidated into rocks; in the course of time these rocks again become raised, to form the dry land with which we are acquainted.

The tides, says Lyell, help in this work. Tidal currents aid in carrying the mud out to sea; they aid to a considerable extent in the actual work of degradation, and thus contribute their quota to the manufacture of stratified rocks. Such is the modest *rôle* which Lyell has assigned to the tides, and no doubt the majority of geologists have acquiesced in this doctrine. Nor can there be any doubt that this is a just view of tidal action at present. That it is a just view of tidal action in past times is what I now deny. Lyell did not know—Lyell could not have known—that our tides are but the feeble surviving ripples of mighty tides with which our oceans once pulsated. Introduce these mighty tides among our geological agents, and see how waves and storms, rivers and glaciers, will hide their diminished heads.

I must attempt to illustrate this view of tidal importance in ancient geological times. Let me try by the aid of the tides to explain the great difficulty which every one must have felt in regard to Lyell's theory. I allude to the stupendous thickness of the Palæozoic rocks.

Look back through the Corridors of Time in the manner in which they are presented to us in the successive epochs of geology. We pass rapidly over the brief career of prehistoric man; then through the long ages of Tertiary rocks, when the great mammals were devel-

oped; back again to the much earlier period when colossal reptiles and birds were the chief inhabitants of the earth; back again to those still earlier ages when the luxuriant forests flourished that have given birth to the coal-fields; back once more to the age of fishes; back finally to those earliest periods when the lowest forms of life began to dawn in the Palæozoic era.

As we date remote ages astronomically by the distance of the moon, so we date remote ages geologically by the prevailing organic life. It is a great desideratum to harmonize these two chronological systems, and to find out, if possible, what lunar distance corresponds to each geological epoch. In the whole field of natural science there is no more noble problem. Take, for example, that earliest and most interesting epoch when life perhaps commenced on the earth, and when stratified rocks were deposited five or ten miles thick, which seem to have contained no living forms higher than the humble Eozoön, if even that were an organized being. Let us ask what the distance of the moon was at the time when those stupendous beds of sediment were deposited in the primeval ocean. We have in this comparison every element of uncertainty except one. The exception is, however, all-important. We know that the moon must have been nearer to the earth than it is at present. There are many very weighty reasons for supposing that the moon must have been very much nearer than it is now. It is not at all unlikely that the moon may then have been situated at only a small fraction of its present distance. My argument is only modified, but not destroyed, whatever fraction we may take. We must take some estimate for the purpose of illustration. I have had considerable doubts what estimate to adopt. I am desirous of making my argument strong enough, but I do not want to make it seem exaggerated. At present the moon is 240,000 miles away; but there was a time when the moon was only one sixth part of this, or, say, 40,000 miles away. That time must have corresponded to some geological epoch. It may have been earlier than the time when the Eozoön lived. It is more likely to have been later. I want to point out that, when the moon was only 40,000 miles away, we had in it a geological engine of transcendent power.

On the primitive oceans the moon raised tides as it does at present; but the 40,000-mile moon was a far more efficient tide-producer than our 240,000-mile moon. The nearer the moon the greater the tide. To express the relation accurately we say that the efficiency of the moon in producing tides varies inversely as the cube of its distance. Here, then, we have the means of calculating the tidal efficiency for any moon-distance. The 40,000-mile moon being at a distance of only one sixth of our present moon's distance, its tidal efficiency would be increased $6 \times 6 \times 6$ fold. In other words, when our moon was only 40,000 miles away, it was 216 times as good a tide-producer as it is at present.

The height to which the tides rise and fall is so profoundly modified by the coasts and by the depth of the sea, that at present we find at different localities tides of only a few inches and tides of sixty or seventy feet. In ancient times there were no doubt also great varieties in the tidal heights, owing to local circumstances. To continue our calculations we must take some present tide. Let us discard the extremes just indicated and take a moderate tide of three-feet rise and three-feet fall as a type of our present tides. On this supposition, what is to be a typical example of a tide raised by the 40,000-mile moon? If the present tides be three feet, and if the early tides be 216 times their present amount, then it is plain that the ancient tides must have been 648 feet.

There can be no doubt that in ancient times tides of this amount, and even tides very much larger, must have occurred. I ask the geologists to take account of these facts, and to consider the effect—a tidal rise and fall of 648 feet twice every day. Dwell for one moment on the sublime spectacle of a tide of 648 feet high, and see what an agent it would be for the performance of geological work! We are now standing, I suppose, some 500 feet above the level of the sea. The sea is a good many miles from Birmingham, yet if the rise and fall at the coasts were 648 feet, Birmingham might be as great a sea-port as Liverpool. Three quarters tide would bring the sea into the streets of Birmingham. At high tide there would be about 150 feet of blue water over our heads. Every house would be covered, and the tops of a few chimneys would alone indicate the site of the town.

In a few hours more the whole of this vast flood would have retreated. Not only would it leave England high and dry, but probably the Straits of Dover would be drained, and perhaps even Ireland would in a literal sense become a member of the United Kingdom. A few hours pass, and the whole of England is again inundated, but only again to be abandoned.

These mighty tides are the gift which astronomers have now made to the working machinery of the geologist. They constitute an engine of terrific power to aid in the great work of geology. What would the puny efforts of water in other ways accomplish when compared with these majestic tides and the great currents they produce?

In the great primeval tides will probably be found the explanation of what has long been a reproach to geology. The early Palæozoic rocks form a stupendous mass of ocean-made beds which, according to Professor Williamson, are twenty miles thick up to the top of the silurian beds. It has long been a difficulty to conceive how such a gigantic quantity of material could have been ground up and deposited at the bottom of the sea. The geologists said, "The rivers and other agents of the present day will do it if you give them time enough." But, unfortunately, the mathematicians and the natural philosophers would not give them time enough, and they ordered the geologists to "hurry

up their phenomena." The mathematicians had other reasons for believing that the earth could not have been so old as the geologists demanded. Now, however, the mathematicians have discovered the new and stupendous tidal grinding-engine. With this powerful aid the geologists can get through their work in a reasonable period of time, and the geologists and the mathematicians may be reconciled.

I have here a large globe to represent the earth, and a small globe suspended by a string to represent the moon. At the commencement of the history the two globes were quite close; they were revolving rapidly, and the moon was constantly over the same locality on the primeval earth. I do not know where that locality was; it was probably the part of the earth from which the moon had been detached. No doubt it was somewhere near the equator, but the distinction of land and water had not then arisen. Around the primeval earth the moon revolved in three hours; the earth also revolved in three hours, so that the moon constantly remained over the red region. This I can illustrate by holding the small globe which represents the moon in one hand, and making the large globe which represents the earth revolve by the other.

This state of things formed what is known as unstable dynamical equilibrium. It could not last. Either the moon must fall back again on the earth, and be reabsorbed into its mass, or the moon must commence to move away from the earth. Which of these two courses was the moon to take? The case is analogous to that of a needle balanced on its point. The needle must fall some way, but what is to decide whether it shall fall to the right or to the left? I do not know what decided the moon, but what the decision was is perfectly plain. The fact that the moon exists shows that it did not return to the earth, but that the moon adopted the other course, and commenced its outward journey.

As the moon recedes, the period which it requires for a journey round the earth increases also. Initially that period was but three hours, and it has increased up until our present month of six hundred and fifty-six hours.

The rotation of the earth has been modified by the retreat of the moon. Directly the moon began to retreat, the earth was no longer under an obligation to keep the same face thereto. When the moon was at a certain distance, the earth made two rotations for every revolution that the moon made. Thus, as I carry the small globe round the large globe, the latter makes two revolutions for one revolution of the small globe. Still the moon gets farther and farther away, until the earth performs three, four, or more rotations for each of the moon's revolutions. Do not infer that the rate of the earth's rotation is increasing; the contrary is the fact. The earth's rotation is getting slower, and so is that of the moon; but the retardation of the moon is much greater than that of the earth. Even though the rotation of

the earth is much more than the primitive three hours, yet that of the moon has increased to several times the rotation of the earth.

The moon recedes still farther and farther, and at length a noticeable epoch is reached, to which I must call attention. At that epoch the moon is so far out that its revolution takes twenty-nine times as long as the rotation of the earth. The month was then twenty-nine times the day. The duration of the day was less than the present twenty-four hours, but I do not believe it was very much less. The time we are speaking of is not very remote, perhaps only a very few million years ago. The month was then in the zenith of its glory. The month was never twenty-nine times as long as the day before. It has never been twenty-nine times as long as the day since. It will never be twenty-nine times as long as the day again.

Resuming our history, we find the moon still continuing to revolve in an ever-widening circle, the length of the month and of the day both increasing. The ratio of the day to the month was still undergoing a change. When the moon was a little farther off, the earth only revolved twenty-eight times instead of twenty-nine times in one revolution of the moon. Still, the velocity of the earth abates until it only makes twenty-seven revolutions in one revolution of the moon. This is an epoch of especial interest, for it is the present time. In the present order of things the moon revolves round the earth once while the earth rotates twenty-seven times. This has remained sensibly true for thousands of years, and no doubt will remain sensibly true for thousands of years to come, but it will not remain true indefinitely. Wondrous as are the changes which have occurred in times past, not less wondrous are the changes which are to occur in time to come. The tides have guided our gropings into the past; they will continue to guide our researches to make a forecast of the future.

Farther and farther will the moon retreat, and more and more slowly will the earth revolve. But we shall not pause at intervening stages; we shall try to sketch the ultimate type to which our system tends. In the dim future, many millions of years distant, the final stage will be approached. As this stage draws nigh, the rotation of the earth will again approach to equality with the revolution of the moon. From the present month of twenty-seven days we shall pass to a month of twenty-six days, of twenty-five days, and so on, until eventually we shall reach a month of two days, and lastly a month of one day. When this state has been attained the earth will constantly turn the same region toward the moon. I do not know what is the locality on the earth which is destined for this distinction.

Here you see that the first state and the last state of the earth-moon history are in one sense identical. In each case the same face of the earth is constantly directed toward the moon. In another way, how different are the first stage and the last! At the beginning the day and the month were both equal, and they were each three hours.

At the end the day and the month will be again equal, but they will each be 1,400 hours. The moon will then go round the earth in 1,400 hours, while the earth will rotate on its axis in the same time. In other words, the day is destined in the very remote future to become as long as fifty-seven of our days. This epoch will assuredly come if the universe lasts long enough. When it has come it will endure for countless ages. It would endure for ever if the earth and the moon could be isolated from all external interference.

We heard a great deal a few years ago about the necessity of shortening the hours of labor. I wish to point out that the social reformers who are striving to shorten the hours of labor are pulling one way, while the moon is pulling the other. The moon is increasing the length of the day. The change will be very gradual, but none the less is it inevitable. Where will the nine-hours' movement be when the day has increased to 1,400 hours? This will be a very serious matter, and there is only one way by which it can be avoided. The question is one rather for engineers than for astronomers; but I can not help throwing out a suggestion. My advice is: Anchor the moon, and keep it from going out. If you can do this, and if you can also provide a brake by which the speed of the moon can be controlled, then you will be able for ever to revel in the enjoyment of a twenty-four-hour day.

Should this engineering feat never be accomplished, then we have only the 1,400-hour day to look forward to. Nor is there anything untoward in the prospect, when we take natural selection as our comforter. By natural selection man has become exactly harmonized with his present environment. No doubt natural selection moves at a dignified pace, but so in all truth does tidal evolution. Natural selection and tidal evolution have advanced *pari passu* through all the past millions of geological time. They will advance *pari passu* through all the ages yet to come. As the day lengthens, so will man's nature gradually change too, without any hardship or inconvenience. All that is necessary is plenty of time. Should we think it a hardship that our children should have a day of twenty-four hours and one second instead of twenty-four hours? That the day enjoyed by our grandchildren should be a second longer than the day of our children? That the day of our great-grandchildren should be a second longer still, and so on continually? This would be no inconvenience whatever. No one except the astronomers would be able to detect the change, and daily life would be unaltered. Yet, carry on this process for only 150,000,000 years, and we shall find that the whole change of the day from twenty-four hours to 1,400 hours has been accomplished. The actual rate of change is indeed much less than this, and is at present so small that astronomers can hardly even detect it.

Our remote posterity will have a night 700 hours long, and when the sun rises in the morning 700 hours more will elapse before he can

set. This they will find a most suitable and agreeable arrangement. They will look back on our short periods of rest and short periods of work with mingled curiosity and pity. Perhaps they will even have exhibitions of eccentric individuals able to sleep for eight hours, work for eight hours, and play for eight hours. They will look on such curiosities in the same way as we look on the man who undertakes to walk a thousand miles in a thousand hours.

I am beyond all things anxious to give you the impression that I am not indulging in any mere romance. No doubt the various figures I have mentioned are but estimates. They may be found to require correction—perhaps large correction; but the general outline of the theory must be true. Should any traces of doubt still linger in the mind of some prejudiced person, let me finally dissipate them. Perhaps some caviler may say: "Where are the proofs of all this action of the tides? How do you know that the tides are sufficiently powerful to produce such changes?" I believe I have shown this abundantly, but some people require a great deal of conviction. I have therefore kept my best argument for the end.

For an overwhelming proof of tidal efficiency I shall summon the heavens themselves to witness, and I shall point to the stupendous task which tides have already accomplished. As the moon has made and is making tides on the earth, so the earth once raised tides on the moon. These tides have ceased for ages; their work is done; but they have raised a monument in the moon to testify to the tidal sufferings which the moon has undergone. To that monument I now confidently appeal. The moon being much smaller than the earth, the tides on the moon produced by the earth must have been many times as great as the tides on our earth produced by the moon. It matters not that the moon now contains no liquid ocean. Nor does it matter whether the moon ever had a liquid ocean. In very ancient days the moon was not the hard, rigid mass which it now appears. Time was when the volcanoes raged on the moon with a fury which nothing on our earth at present can parallel. The moon was then in a soft or a more or less fluid condition, and in this viscous mass the earth produced great tides.

Great tides in truth they were, for the earth is eighty times as heavy as the moon. On the other hand, the moon is only one fourth the diameter of the earth; so that the actual height of the tides on the moon would be still many times as great as the tides on the earth. When the moon was nearer to us, as it was in early ages, those tides were still greater. Think for one moment of what a lunar tidal wave of such magnitude would be capable! This wave is perhaps of molten lava; it would tear over the surface with terrific power, and anything that friction could accomplish that great current would do. That tidal current has done its work; even if the moon were fluid at the present day, it could no longer be distracted by tides.

Remember, it is not the mere presence of the tide which produces friction. It is the action of the tide in rising and in falling which accomplishes the work. If, therefore, the moon moved so that it was always high tide at the same place, the tides could produce no further effect. The spot where the tide is high on the moon is the spot which is toward the earth. It hence follows that the action of the tides will cease when the moon constantly directs the same face to the earth. The moon has thus at length gained a haven of rest from a tidal point of view. No doubt the moon has a high tide and it has a low tide, but those tides no longer ebb and flow: the moon has succumbed to the incessant action of friction, and has assumed the only attitude which can relieve it from incessant disturbance.

For many centuries it had been an enigma to astronomers why the moon should always turn the same face to the earth. It could be shown that there were many million chances to one in favor of this being due to some physical cause. The ordinary theory of gravitation failed to explain the cause. Every one had noticed this phenomenon. Yet the explanation was never given till lately. It was Helmholtz who showed that this was a consequence of ancient tides, and this simple and most satisfactory explanation had been universally accepted. The constant face of the moon is a living testimony to the power of the tides. What tides have accomplished on the moon is an earnest of what tides will accomplish on the earth.

In the great conflict of the tides the earth has already conquered the moon, and forced the moon to render perpetual homage as a token of submission. Remember, however, that the earth is large and the moon is small. Yet, small though the moon is, it gallantly struggles on. "You have forced me," cries the moon to the earth, "to abandon the rotation with which I was originally endowed; you have compelled me to rotate in the manner you have dictated. I will have my revenge. It is true I am weak, but I am unrelenting; day by day I am exhausting you by the tides with which I make you throb. The time will assuredly come, though it may not be for millions of years, when you shall be forced to make a compromise. When that compromise is made the turmoils of the tides will cease; our mutual movements will be adjusted. With equal dignity we shall each rotate around the other; with equal dignity we shall each constantly bend the same face to the other."

There is another point to be considered. We must not forget that there is a sun in the heavens as well as a moon. The sun also produces tides in the earth. Those tides were much smaller than the lunar tides, so that we could afford to neglect them. But we have seen that the lunar tides will gradually decrease to nothing. It behooves us then to consider what the solar tides can effect which shall be worthy of our attention. In a lecture which I gave here some years ago, I made allusion to the discovery of the satellites of Mars.

I mentioned that one of the satellites of Mars presented a phenomenon unparalleled in the solar system. The satellite revolved around Mars in a period of seven hours, while Mars himself rotated on his axis in a period of twenty-four hours. We here actually find the moon of Mars rotating around Mars in much less than one of Mars's own days. This was a most curious and unexpected circumstance, but the observations of the discoverer, Asaph Hall, placed the great fact beyond any doubt. The mystery has now been explained. It is due to the action of the solar tides on Mars. Nay, more, we can actually foresee that at some incredibly remote future time our earth and moon are destined to present the same movements which have seemed so anomalous in Mars.

Left to themselves the earth and the moon would have remained for ever in the condition of compromise. The moon would have revolved round the earth in 1,400 hours. The earth would have rotated on its axis in 1,400 hours also. But now the solar tides intervene. They have little effect upon the moon ; it revolves as before, but the solar tides begin to retard the earth still further. Instead of a period of 1,400 hours, the earth will have a still longer day, so that finally the moon revolves more rapidly around the earth than the earth rotates on its axis.

It seems to me that the episode I have mentioned is one of the most interesting in the whole of modern astronomy. We have first a most delicate telescopic discovery of the tiny satellite of Mars and of its anomalous movements. We then have a beautiful explanation of how this anomalous motion has arisen from the action of solar tides. Finally, we have in this miniature system of Mars a foreshadowing of the ultimate destiny of our earth and our moon.

Do I say the ultimate destiny? Nothing is ultimate in nature. The moon and the earth would have come to an amicable and a final agreement had they been let alone. But now the sun has intervened and disturbed the earth's rotation. The truce once broken, the moon again produces tides on the earth, the earth reacts on the moon, and a whole chain of complicated movements are the consequence. I shall not now attempt to trace the further progress of events.

I have dealt with very large figures in this lecture, and perhaps I have taxed your imagination by my demands that you should conceive of periods of tens of millions of years. Yet, after all, let us look at the results in their true proportion, compared with the universe in which our lot has been cast.

Truly we have been engaged with a very trifling matter. Is not our earth one of the most insignificant bodies in the universe? And our moon is much smaller still. Nor is it even the life-history of our earth that we have been considering, it is merely a brief episode in that history. What are the periods of time we have been discussing when compared with those infinitely longer periods during which the

solar system has been evolved? Even the solar system is but one out of one hundred million such systems, each of which has its own life-history. Viewed in their true proportions, the phenomena I have described are but of infinitesimal importance, and the time they have occupied is merely ephemeral.

No doubt we have only dwelt upon the tides on the earth and the tides in the moon, which have been of such infinite importance. But do not suppose that tides are confined to the earth and to the moon. So far as we know, every body in the universe is capable of producing, and actually does produce, tides in every other body. Every planet throbs in response to the tides produced in it by every other planet. Every star has a distinct tidal wave produced in it by every other star. You may say that such tides are infinitesimal, but you must remember that infinitesimal causes, sufficiently often repeated, can achieve the mightiest effects.

We know that tides have wrought our solar system into its present form; and are we to say that the wondrous powers of the tides have no grander scope for their exercise? I prefer to believe that tides operate far and wide through the universe, and that in the recognition of the supreme importance of tidal evolution we mark a great epoch in the history of physical astronomy.—*Nature.*

## EPIDEMIC CONVULSIONS.*

By DAVID W. YANDELL,
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EXTRAORDINARY interest was excited in the popular mind of Kentucky, at an early day, by a form of convulsive disease, which, though it had been witnessed elsewhere in the world, had never before assumed a shape so decidedly epidemic. Among the Camisards, or French prophets, who appeared in the mountains of the Cevennes toward the close of the seventeenth century, the subjects, when about to receive the gift of prophecy, were often affected with trembling and fell down in swoons. When the fit came, no matter where they were, they fell, smiting their breasts with their hands, crying for mercy, and imprecating curses on the Pope. They were finally, after an obstinate struggle, put down by their insane persecutor, Louis XIV.†

Epidemic convulsions prevailed in Scotland, half a century later.

* The larger part of the materials contained in this paper were collected by my father, the late L. P. Yandell, M. D., and were intended to be embraced in the "Medical History of Kentucky," a work on which he was engaged at the time of his death. I have done little more than arrange and place them in their proper chronological order.—D. W. Y.

† "Encyclopædia Americana," article "Cevennes."

Multitudes, under pungent preaching, were violently agitated, uttering loud cries, shaking, trembling, bleeding at the nose, the minister promoting the uproar by urging them not to stifle their convictions. The shriek, or the shout, it is stated, never rose from one, but that others joined the outcry.* The early career of John Wesley is well known to have been marked by similar disorders. In his journal he records numerous instances of men and women dropping to the ground under his preaching "as if struck by lightning," ten or a dozen praying at once. They had also prevailed extensively in New Zealand half a century before they became epidemic in Kentucky. The elder Edwards has left an instructive account of the bodily agitations which accompanied the revivals of religion from 1735–'42. Many instances are given of fainting, falling, trance, numbness, outcries, and convulsions, and he relates that some of the subjects lost their reason.† The epidemic of Kentucky spread more widely, and persisted for a longer time, as well as in more extravagant forms. It continued to reappear for several years, and involved a district of country extending from Ohio to the mountains of Tennessee, and even into the old settlements in the Carolinas. Lorenzo Dow relates that, at a religious meeting in the court-house of Knoxville, when the Governor of Tennessee was present, he saw one hundred and fifty people "jerking" at one time. But at other places the frenzy reached a greater height. It was computed that, at a religious meeting in Kentucky, not less than three thousand persons fell in convulsions to the ground.

The extraordinary religious excitement in which these nervous disorders took their rise commenced in Logan County, Kentucky, under the preaching of Rev. James McGready, described as a man of "hideous visage and thunder-tones," with a highly impassioned style of eloquence.‡ The excitement abated soon, but was renewed in a more intense form three years later, and continued to grow and deepen until it reached its height about the year 1800. Its effects were described by this fiery preacher as at that time "exceeding everything his eyes had ever beheld upon earth." Families came in wagons, forty, fifty, and one hundred miles to attend the meetings, and it became necessary to establish camps for their accommodation. These camp-meetings generally continued four days, from Friday to Tuesday morning, but sometimes they lasted a week. One succeeded another in rapid succession, and thus the fervor of religious feeling was kept up. The woods and paths leading to the camp-ground seemed alive with people. "The laborer," says Dr. Davidson, in the work just quoted, "quitted his task; age snatched his crutch; youth forgot his pastimes; the plow was left in the furrow; the deer enjoyed a respite upon the mountains; business of all kinds was suspended; dwelling-houses were deserted; whole neighborhoods were emptied; bold hunters, and so-

* Rees's "Cyclopædia," article "Imitation." † Edwards on "Revivals."

‡ Dr. Davidson's "History of the Presbyterian Church in Kentucky."

ber matrons, young men, maidens, and little children, flocked to the common center of attraction; every difficulty was surmounted, every risk ventured, to be present at the camp-meeting."

The concourse became immense. At one of these assemblages the attendance was computed at twenty thousand souls. And here were united all the elements best suited to stir the emotional nature of man and to derange his nervous system. The spectacle at night, as Dr. Davidson depicts it, was one of the wildest grandeur. With great beauty of description he says: "The glare of the camp-fires, falling on a dense assemblage of heads simultaneously bowed in prayer, and reflected back from long ranges of tents upon every side; hundreds of candles and lamps suspended among the trees, together with numerous torches flashing to and fro, throwing an uncertain light upon the tremulous foliage; the solemn chanting of hymns swelling and falling on the night wind; the impassioned exhortations, the earnest prayers, the sobs, shrieks, or shouts, bursting from persons under intense agitation of mind; the sudden spasms which seized upon scores, and unexpectedly dashed them to the ground—all conspired not only to invest the scene with terrific interest, but to work up the feelings to the highest pitch of excitement."* To these circumstances, that tended so powerfully to excite the nervous centers, we have to add others which gave intensity to their effect. The meetings were protracted to a late hour in the night, keeping the feelings long upon the stretch. A reverent and general enthusiasm ascribed the bodily agitations to a mysterious, divine agency. The preaching was fervid and impassioned in the extreme. Many of the preachers, unable to control their emotions during the sermon, went around in "a singing ecstasy," shouting and shaking hands with others, as much excited as themselves. In this way everything was done to "heap fuel on the fire," and it was at such meetings that thousands fell in convulsions to the ground.

Some of the actors in these strange scenes have left records of the state of their minds, which show that they were in a condition bordering on insanity, if not actually insane. One of them relates that, while under conviction on account of his sins, he went about the woods for two years, through rain and snow, "roaring, howling, praying, day and night." And when light and hope broke in at last upon his mind, which he describes as a "rushing, mighty wind, that descended from heaven, and filled his whole being," he went shouting over the encampment all night and a great part of the next day. He continues: "I now made the mountains, woods, and canebrakes ring louder with my shouts and praises than I once did with my howling cries; I never fell on my knees in secret but the Lord poured out his power, so that I shouted out aloud. Sometimes I shouted for two or three hours, and even fainted under the hand of the Lord. I was ready to cry out at the name of Jesus. The brightness of heaven rested continually upon

* Dr. Davidson's "History of the Presbyterian Church in Kentucky."

my soul, so that I was often prevented from sleeping, eating, reading, writing, or preaching. I would sing a song, or exhort a few minutes, and the fire would break out among the people. I have spent nine nights out of ten (besides my day meetings, and long, hard rides) with the slain of the Lord." *

Granade is the preacher who gives this description of himself, which is also descriptive of his times. He was a stormy orator who drew great crowds wherever he went. He admits that he went by the name of "the distracted preacher," but says that at one of his meetings "the people fell as if slain by a mighty weapon, and lay in such piles and heaps that it was feared they would suffocate, and that in the woods." So violent was his manner, stamping with his feet and smiting with his hands, that he often broke down the stands erected for him in the woods. Once, it is told of him, he was addressing a class-meeting in the upper story of a dwelling-house, when the room below was crowded with worshipers, and, being in what the historian calls "one of his big ways," he exclaimed, "I feel like breaking the trigger of hell!" and at the same time gave a tremendous stamp with his foot which actually broke one of the joists. The people below, hearing the sudden crash, ran screaming to the door, some of them really imagining, as the writer of all these events relates, "that hell had overtaken them." †

Granade was of an excitable temperament and vivid imagination. His person was commanding, and, with a sounding voice and most impassioned manner, his oratory produced startling effects.

Another feature of these excited meetings, which served still further to intensify the feelings of the people who attended them for days and nights together, was the part taken in them by children. Nothing was more affecting to the congregations than the sight of a little boy or girl on a log or stump, passionately exhorting the multitude. Thus, a boy, who appeared to be about twelve years of age, is described as having retired from the stand at Indian Creek, Ohio, during the sermon, and, mounting a log and raising his voice to a high pitch, soon had nearly all the congregation with him. "With tears streaming down his cheeks, he cried aloud to the wicked, warning them of their danger, denouncing their certain doom if they persisted in their sins, expressing his love for their souls, and desire that they should turn to the Lord and be saved." A man on each side held the boy up, and he spoke for about an hour. When quite exhausted, and language failed to give utterance to his emotions, the little orator raised his hands, and, dropping his handkerchief wet with tears and perspiration, cried out, "Thus, O sinner, shall you drop into hell, unless you forsake your sins and turn to the Lord." At that moment, the writer of this account continues, "Some fell like those who are shot in battle, and the work spread in a manner which human language can not describe." ‡

* McFerrin's "Methodism in Tennessee." † Ibid. ‡ Ibid.

McNemar instances boys of eight and ten years, and the Rev. John Lyle mentions one of seven, who called on sinners to repent, with an eloquence singularly overpowering. Possessed by one dominant idea, the people gave themselves up to the wildest enthusiasm, and it was no uncommon thing for them to spend the whole night in religious orgies such as have been described.*

The spectacle of persons falling down in a paroxysm of feeling was first exhibited at Gasper River Church, in one of McGready's congregations in the summer of 1779. The movement proved highly contagious and spread in all directions. After a rousing appeal to the feelings of the listeners, and especially during spirited singing, one and another in the audience would fall suddenly to the ground and swoon away. Not only nervous women, but robust young men were overpowered. Some, continues the historian, fell suddenly as if struck by lightning, while others were seized with a universal tremor before they fell shrieking.† Dr. Blythe, who often witnessed scenes of this sort, assured Dr. Davidson that he had once felt the sensation himself, and only overcame the tendency to convulsion by a determined effort of his will. A few shrieks never failed to put the assembly in motion, and set men and women to falling all around. A sense of "pins and needles" was complained of by many of the subjects, and others felt a numbness of body, and lost all volitional control of their muscles. It soon grew into a habit, and those who had once fallen were ready to fall again under circumstances by no means exciting. Women who had suffered repeated attacks sometimes fell from their horses on their way to or from the meeting-house, while relating their past religious exercises.

The condition in some of the subjects was catalcptic, lasting generally from a few minutes to two or three hours; but in a few cases it continued many days. Others were violently convulsed as in hysteria or epilepsy, "wrought hard in fitful nervous agonies, the eyes rolling wildly." Most were speechless, but some were capable of conversing throughout the paroxysm. The extremities were cold; the face was pale or flushed, the breathing hard. Sensibility was annulled. Mr. Lyle, one of the prominent preachers of the times, having been furnished by Dr. Warfield with a vial of hartshorn, applied it to a stout young man who was lying flat on his back, and, inadvertently, let some of the fluid run into his nostrils; but he took not the slightest notice of it.‡ Others who fell hard to the ground, or in running encountered stumps or trees, felt no pain from the violence. So many fe'l at Cabin Creek camp-meeting, it is related, that to prevent their being trodden upon "they were laid out in order on two squares of the meeting-house, covering the floor like so many corpses. At Paint Creek Sacrament two hundred were estimated to have fallen; at Pleasant Point three hundred were prostrated; while at Cane Ridge, as has

* Davidson, *op. cit.* † Lyle's "Diary." ‡ Davidson's "History."

been stated, the number who fell was believed to have reached three thousand.

The "jerks," as they were termed, presented some novel and remarkable features. Their first occurrence is reported to have been at a sacramental meeting in East Tennessee, where several hundred people of both sexes were seized with this strange, convulsive movement. The Rev. B. W. Stone has left a vivid description of it. Sometimes, he says, the subject was affected in a single member of his body, but at others the spasms were universal. When the head alone was affected, it would be jerked from side to side so quickly that the features of the face could not be distinguished. When the whole system was affected, he continues, "I have seen the person stand in one place, and jerk backward and forward in quick succession, the head nearly touching the floor behind and before. All classes, saints and sinners, the strong as well as the weak, were thus affected. I have seen some wicked persons thus affected, and all the time cursing the jerks, while they were thrown to the earth with violence."*

The first form in which these spasmodic movements made their appearance was that of a simple jerking of the arms from the elbow downward. When they involved the entire body, they are described as something terrible to behold. The head was thrown backward and forward with a celerity that alarmed spectators, causing the hair, if it was long, "to crack and snap like the lash of a whip."†

The most graphic description of the "jerking exercise" was written by the Rev. Richard McNemar, an eye-witness of the frenzy, as well as an apologist, believing it to be a display of Divine favor. In his "History of the Kentucky Revival" he says: "Nothing in nature could better represent this strange and unaccountable operation than for one to goad another, alternately on every side, with a piece of red-hot iron. The exercise commonly began in the head, which would fly backward and forward, and from side to side with a quick jolt, which the person would naturally labor to suppress, but in vain; and the more any one labored to stay himself, and be sober, the more he staggered, and the more his twitches increased. He must necessarily go as he was stimulated, whether with a violent dash on the ground, and bounce from place to place like a foot-ball, or hop round with head, limbs, and trunk twitching and jolting in every direction, as if they must inevitably fly asunder. And how such could escape without injury was no small wonder to spectators. By this strange operation the human frame was commonly so transformed and disfigured as to lose every trace of its natural appearance. Sometimes the head would

* McFerrin's "Methodism in Tennessee."

† Dr. Davidson, who relates this singular fact, felt it necessary to authenticate the statement by referring to eye- and ear-witnesses of its reality. I remember to have heard my grandmother describe, when I was but a little boy, the same thing as occurring in a woman at a camp-meeting near her home in Tennessee, in 1810.

be twitched right and left to a half-round with such velocity that not a feature could be discovered, but the face appeared as much behind as before. Head-dresses were of little account among the female jerkers. Handkerchiefs, bound tight round the head, were flirted off with the first twitch, and the hair put into the utmost confusion; this was of very great inconvenience, to redress which the generality were shorn, though directly contrary to their confession of faith. Such as were seized with the jerks were wrested at once, not only from under their own government, but from that of every one else, so that it was dangerous to attempt confining them or touching them in any manner, to whatever danger they were exposed. Yet few were hurt, except such as rebelled against the operations through willful and deliberate enmity, and refused to comply with the injunctions which it came to enforce."

The same writer gives the history of a case of jerks as follows, and no case could illustrate more strikingly the nature of the affection:

A young man, of a pious family, the son of a tanner, feigned sickness one Sunday morning to avoid going that day to camp-meeting. He kept his bed until he was assured that all the family, except a few negro children, had left the premises, and was much pleased at the success of his stratagem. As he lay quietly in his bed, his thoughts naturally turned to the camp-meeting in progress. The assembled multitude, excited, agitated, convulsed, rose up vividly before his mind. All at once, while occupied with the scene, he felt himself violently jerked out of bed, and dashed round the walls in a manner utterly beyond his control. Prayer, he remembered, was deemed efficacious in such circumstances, and he fell upon his knees in the hope that it would prove a sedative in his case. It turned out as he hoped, and he returned to bed, happy at finding the spirit exorcised. But the enemy soon returned; the jerks were as bad as ever, but were again allayed by prayer. Dressing himself, he now went to the tan-yard, and set about currying a hide to occupy his mind. He rolled up his sleeves, and, grasping his knife, was about to commence the operation, when suddenly the knife was flirted out of his hand, and he was jerked violently backward, over logs and against fences, as before. Gaining relief by resorting once more to prayer, he ventured to resume his occupation, but was again seized with convulsions, and at last forsook the tan-yard and betook himself to strong cries for mercy, at which he was found engaged by the family on their return from the meeting in the evening.*

Another characteristic example is related by a writer in the "Gospel Herald"†:

A gentleman and lady of some note in the fashionable world were attracted by curiosity to the camp-meeting at Cane Ridge. They indulged in many contemptuous remarks on their way, about the poor

* Davidson, *op. cit.* † "History of Methodism in the United States."

infatuated creatures who rolled over screaming in the mud, and promised jestingly to stand by and assist each other in case that either should be seized with the convulsions. They had not been long on the ground, looking upon the strange scene before them, when the young woman lost her consciousness and fell to the ground. Her companion, forgetting his promise of protection, instantly forsook her and ran off at the top of his speed. But flight afforded him no safety. Before he had gone two hundred yards, he too fell down in convulsions, "while a crowd flocked round him to witness his mortification and offer prayers in his behalf."

These nervous disorders assumed many other grotesque forms besides those which have been described. The subjects often rolled over and over on the ground, or ran violently until worn out with the exertion. Hysterical laughter was another modification. Instances of laughter were only occasional at first, but it grew, until in 1803 the "holy laugh" was introduced systematically as a part of religious worship. Sometimes half the congregation, apparently in the most devout spirit, were to be heard laughing aloud in the midst of a lively sermon. As the excitement grew, the infatuated subjects took to dancing, and at last to barking like dogs. McNemar says they actually assumed the posture of dogs, "moving about on all-fours, growling, snapping the teeth, and barking with such an exactness of imitation as to deceive any one whose eyes were not directed to the spot."* Nor were the people who suffered so mortifying a transformation always of the vulgar classes; persons of the highest rank in society, on the contrary, men and women of cultivated minds and polite manners, found themselves, by sympathy, reduced to this degrading situation.

The "barks" were looked upon at first as a chastisement for remissness of duty, and the only way to escape them was to engage in the holy dance. But, from being regarded as marks of guilt, these wretched exercises came to be esteemed "tokens of Divine favor, and badges of special honor."† With these manifestations the insanity reached its height in about three years after it began to show itself.

It was one of the popular beliefs of the times that certain instincts or conditions of the system would avert these nervous attacks. Thus it was held that a woman with a child in her arms, or conscious of approaching maternity, was in no danger. But there was no truth in the supposition. The maternal instinct, at least, had no protective efficacy. An instance is related where a woman mounted the stand, with an infant in her arms, for the sake of a better prospect, and that being suddenly seized she fell backward, dropping her child. Some one fortunately saw the danger in time to seize and save the child before it fell to the ground.‡

A large proportion of the members of every congregation had power to resist the convulsive tendency. In a great majority, no such

* Davidson. † Ibid. ‡ Ibid.

tendency probably existed; but where there was a conscious impulse toward the convulsions it could be restrained by most persons before it had been yielded to too long. Dr. Blythe had but little of the disorder in his church. He discountenanced the wild enthusiasm from the beginning, and threatened to have any one who became convulsed turned out-of-doors. The religious frenzy soon began to abate when the clergy set their faces against the stormy exercises. Rev. Joseph Lyle, on the second Sabbath in July, 1803, preached in his church a significant sermon on "Order." The congregation had come together expecting the usual displays of feeling; but though some were angered by his doctrines, and some strove to promote the confusion of intermingled exercises, only a few "fell," and, altogether, moderation triumphed. This was the first sermon preached against the fanaticism.

It is a remarkable fact that, notwithstanding the intensity and duration of this nervous disorder, no instance is recorded in which permanent insanity resulted from it. Such results were to have been expected; insanity is mentioned by Edwards as having attended the excitement in New England, and it may be that reason was dethroned in some whose cases have not become matters of history. In a few years, after a sounder public opinion began to assert itself, instances of the disorder had become rare, but it was many years before the epidemic entirely ceased.

As to its nature, there was but one opinion among medical men from the beginning. All referred it to a derangement of the nervous system. Dr. Felix Robertson, of Nashville, described the affection in his thesis, published in Philadelphia, in 1805, as a form of chorea. In some cases it took the form of that disease. In others it bore a stronger resemblance to epilepsy; while in a greater number it partook rather of the character of hysteria. It was eminently sympathetic in its nature, as has been so often remarked of these affections. The convulsions once started in a congregation spread quickly through it, until all the fit subjects were convulsed. Repetition greatly increased the proneness to the disorder, which was invited by the masses on the supposition that it was a true religious exercise.

These perverted muscular movements all come under the head of morbid reflex action. By the continued religious fervor, the central portions of the brain, the immediate seat of emotion and feeling, became inordinately excited. The impression, transmitted downward to the spinal cord, threw the muscles of voluntary motion into convulsions. Sensibility, which has its seat in the sensory ganglia, was generally annulled. When the hemispheres became involved, the subjects fell into a state of unconsciousness or coma. In this abnormal condition of the nervous centers, the bare recollection of the distressing scenes was sufficient in many cases to excite the convulsive movements. The former belong to sensori-motor actions; this last is an example of ideo-motor movement; instances of which are afforded by the act of

vomiting, which may be caused by the recollection of disgusting sights or odors. The principle of imitation accounts for the rest. The great nervous centers, in multitudes of people, being in a state of polarity, any unusual exhibition of feeling would throw the more excitable into spasms; and the affection would then spread by sympathy, as hysterical convulsions and chorea are known to spread among girls at boarding-schools. And, as fear has checked these, the epidemic convulsions were checked by reason and common-sense, and finally ceased under the law which limits all violent action.—*Brain.*

## EXTENSION OF THE SIGNAL SERVICE.

By Professor JOHN TROWBRIDGE.

THE Signal Service of the United States performs a great service to science by inculcating the value of scientific investigations. Observations in meteorology were formerly buried in the proceedings of learned societies, and met the eyes only of a few scientific men: now they are discussed at the breakfast-tables of a million people. The departments of physics in our universities and technical schools have reason to thank the Signal Service for leading the public mind to see the importance of physical investigations to the ordinary pursuits of mankind. He, however, who endeavors to raise money at the present time to equip a physical laboratory in connection with a university, will find that the Signal Service still has work to do among the practical business-men of this country—men whose successful prosecution of their commercial enterprises depends upon the economical use of steam, upon careful scientific consideration of atmospheric changes, conditions of heat and moisture, and sanitary laws. There are men of this class who accept what they call progress, without inquiring into the causes of it, and who have never thought of physics as a science to which business is indebted for its successful prosecution. "What is meant by the word physics?" asks the man who consults the paper to discover if the storm-center which has been developed in Texas, and whose progress has been telegraphed, will probably strike his steamship, which is off Cape Hatteras. This steamship has recently been fitted up with the most approved compound engines, which have been perfected by the labors of those physicists, Rankine and Thomson. "What is meant by the word physics?" asks the manufacturer, with a telephone to his ear, listening to a response from his factory. The solicitor for the endowment of a physical laboratory has the satisfaction, even if he fails to obtain a subscription, of feeling that he is a public educator.

It is very probable that any plan for the extension of the Signal

Service would meet with opposition, even among those who would be most benefited by such extension. Yet the demands of science are daily becoming more inexorable, and the progress of meteorology toward the stand-point of an exact science is assured by the labors of those who have charge of the Signal Service.

At one time most of our American colleges and universities conducted meteorological observations. These observations were industriously made and conscientiously carried on, but were very much like private measurements of rain-fall and barometer heights—notes of the first coming of the golden robin in spring—and journals of cold or hot days. Meteorological observations which are not taken simultaneously over extended areas are of little value, save to the compilers of local almanacs. The Signal Service, having relieved four universities of their onerous meteorological responsibilities, doubtless feels indebted to them for pointing the way, and would be grateful if the universities could lead them one step higher, since it is one of the functions of a university to be always a little in advance of the ruling conditions of popular knowledge. Some plan of co-operation might be devised, by which the universities and colleges along our Atlantic sea-coast could aid the Signal Service in testing the value of more delicate investigations upon atmospheric changes than can be carried on at the present Government stations. Harvard University, Yale, Columbia, Princeton Colleges, the University of Pennsylvania, and Johns Hopkins University could, doubtless, provide suitable rooms and experienced assistants for testing the value of simultaneous observations upon various phenomena which are not at present taken into account in weather predictions. We judge at present of climatic changes by observations above-ground ; it may be that the presence of earth-currents of electricity, of fluctuations in the earth's magnetism, of waves of heat through the superficial layers of the earth, may reveal important factors in announcing meteorological changes. Simultaneous observations, upon the slight earthquake-shocks which are continually pulsating beneath the apparently calm surface upon which our great cities are built, may have important relations to conditions of heat and cold. The mere mention of these unobserved phenomena is sufficient to show the state of our ignorance, and to lead us to expect that investigations in physical laboratories will be of practical value in leading the Signal Service to extend its usefulness.

The electrical state of the air is supposed to have great influence upon the proper conditions for fair weather and for storms, and to also affect the states of health and disease ; but no definite information has been collected which bears upon these points. The Signal Service would aid the science of meteorology very greatly by extending observations on the electrical state of the air over large areas of territory.

The apparatus for studying the electricity of the atmosphere is

probably the most delicate and refined of any in the subject of electricity. Sir William Thomson's electrometer is an admirable instrument, wonderful in its details and in its scientific plan. It can be used, however, by any intelligent observer. In principle it consists merely of a suspended aluminum needle which swings between four hollow quadrants. The needle is put in constant contact with the inner coating—which consists of sulphuric acid—of a Leyden-jar, by means of a small wire suspended from the needle. The diagonal quadrants are connected. If one pair is put in connection with the ground and the other pair connected with the body whose electrical state is to be tested, the aluminum needle by its deflection indicates the kind and amount of the electrical state. The needle is provided with a mirror, which allows its deflections to be observed by means of the reflection of a point of light. Although the principle is simple, yet the means for obtaining complete insulation and for keeping a constant charge in the needle are quite complicated. The Leyden-jar can be charged by means of a small Holtz machine, or by means of an induction-coil. A still better method of charging has been adopted by the Continental physicists: this consists in the employment of a miniature water-battery of five hundred or a thousand cells. Small glass vials, similar to those used by the homœopathists, are filled with distilled water, are placed in a wooden box, and are well insulated from each other. A sheet of zinc and copper are soldered together along their edges, and then cut into small couples of zinc and copper. These cells are coupled *seriatim*, or, as it is usually termed, for intensity. The entire battery need not occupy a space of more than a foot and a half square, and can be made even more compact. The statical charge at the terminals of this miniature battery is strong, and a Leyden-jar or a condenser can be easily charged by connecting one terminal of the battery to the inner coating of the condenser and the other to the outside coating. The electrometer-jar is charged, therefore, in this way, by being kept permanently connected with this battery.

The apparatus for collecting the charge of the air, in order to affect the charged needle, consists of an insulated tin can filled with water. The water is allowed to flow from this can by means of an horizontal glass tube, which is drawn out to a comparatively narrow orifice. The can is then connected by an insulated wire to one pair of the quadrants of the electrometer. Since the original charge of the can and the water—all objects are necessarily charged with electricity to a greater or less extent—is dissipated by the flow of the water, the electricity of the air continually renews this loss, and the tin can finally takes the charge of the air in which it is placed. This method is very sensitive, and will detect discharges of lightning by a throb of the electrometer-needle even when the thunder-storm has not yet appeared above the horizon. A method of obtaining continuous registrations of the deflections of the electrometer-needle is necessary. This can

be accomplished by receiving a spot of light, which is reflected from the mirror attached to the needle, upon a cylinder covered with sensitized paper. This cylinder is made to slowly revolve by clock-work, so that twenty-four-hour observations can be obtained. Nothing is so characteristic of modern methods in physical science as continuous registration of physical phenomena. Early observers were forced to content themselves with scattered observations taken at different intervals, and important variations might occur at the times when no observer was watching the apparatus. Now the movements of the human heart can be recorded by a little apparatus which will combine in one curve a thousand continuous observations, and the slightest anomalous fluctuations can be studied from the record which is obtained.

Provided, therefore, with these modern and more refined means of observation, we are in a condition to study the fluctuations of that subtile manifestation of energy which is ever present in the air, and seems to lurk in all matter. The influence of the electrical state of the air upon atmospheric changes is doubtless far-reaching. We are accustomed to think of thunder-storms as the only manifestations of atmospheric electricity; but there are influences which it exerts, more silent than those which are announced by the crackle of lightning, yet none the less extended. A pretty experiment, described by Lord Rayleigh, illustrates the effect of electricity upon the coalescence of rain-drops. A narrow stream of water is allowed to issue from a reservoir and form a parabola, which strikes the ground in drops about four feet from the orifice. When this is a fine stream, it breaks up into a shower of drops at about two feet from the orifice. On rubbing a bit of sealing-wax with a cloth, and presenting the rod of sealing-wax near the stream, the drops immediately cease to separate, and the stream is continuous from the orifice to the point where it strikes the ground. This is a very striking experiment, and undoubtedly has a bearing upon the formation of large drops of rain, which are often noticed during a thunder-storm after a discharge of lightning. Instead of a rod of sealing-wax, a piece of writing-paper can be readily charged by placing it upon a table and rubbing it vigorously with the palm of the hand.

None of the theories which endeavor to explain the source of the electricity of the air are satisfactory. Professor Tait, in a recent lecture, is of the opinion that evaporation is the source. Under the influence of the sun's heat, this operation of nature is conducted on an immense scale, and seems to him to be competent to furnish the supply of atmospheric electricity.

It is maintained by others that the atmosphere of the earth has a permanent charge, which it received in the beginning, or which was developed by cosmical changes; and this charge manifests itself here and there, and fluctuates under different conditions of heat and moist-

ure. Mr. Aiken has lately broached a novel theory of the formation of fogs and rain-clouds, which also has an important bearing upon the theory of atmospheric electricity. He believes that dust, or impalpable saline particles, are necessary for the formation of clouds. Without dust, or these particles, we should always have cloudless skies. To prove this theory, he caused water to evaporate in two receivers, the air in one of which had been passed through cotton-wool and other media, to intercept the dust; in the other the air contained dust. The usual fog which is perceived when water is suddenly evaporated under a receiver was absent in the receiver whose air had been deprived of its dust, but was present as usual in the other receiver. Various experiments of the same nature were tried. Fog suddenly formed in the dust-deprived air of a receiver if a bit of wood was burned, and thus caused to throw off small particles; burning sulphur was very active in producing these fogs. The fogs of London are thus partially caused by the consumption of coal and the evolution of sulphurous gas, and the fogs along the sea-coast by the saline dust formed from the spray.

If this theory is a correct one, our views of the electrical charges upon different layers of air must be modified to a considerable extent. Some experiments are now being made in the Physical Laboratory of Harvard University to test the inductive capacity of dust-films, and also to trace the fluctuations in the electric spark when it is caused to pass through air deprived of its dust, and air which contains impalpable matter. In order to add to our knowledge of the electrical conditions of the air, simultaneous observations are needed at a large number of stations. The cost of fitting up such stations would not fall short of six hundred dollars for each station, and the services of experienced observers would be necessary. It is not likely that the United States Government will establish such stations unless it can be shown that observations upon the electrical state of the air are important in predicting the path of storms. In the mean time, the various colleges in the different States might, by some system of co-operation with the Government, undertake such observations, since there are in nearly every college rooms and observers at command. As soon as it became apparent that the observations thus taken were of value, the interests of commerce would demand that they should become a part of the regular work of the Signal Service.

# THE FUNDAMENTAL PROBLEMS OF PHYSIOLOGICAL CHEMISTRY.*

By Dr. EDMUND DRECHSEL,
PROFESSOR OF MEDICINE AT LEIPSIC.

WHEN the science which endeavors to determine the phenomena of life and their connection was enabled to employ more exact expedients for its observations, the influence which the chemical process exerts on that of life became known. The physical apparatus of the body are preserved in the aggregate state and form, which are necessary for the performance of their functions by a definite chemical composition of the organs and the fluids which saturate them; and the source of the power required by the living body for its movements is to be sought for in the destruction of the compounds of which it is composed. This statement is not only justified by the axioms of science, but it is also confirmed by experience. For, even where the best methods of chemistry are deficient, we meet with phenomena, the appearance of which can only be explained by chemical decomposition. The substances of which the muscle is formed and the manner in which they are arranged are still imperfectly known; of the chemical process which takes place in the sarcous elements, when a muscle passes from rest to the contracted state, we know scarcely anything; still, we can not doubt for a moment that the muscle owes its form to its composition, and its motion to a change of the latter. This is shown by the fact that even by a slight change, which we may produce in the chemical constitution, though it be only a change in the amount of water or salt in the muscle, its elasticity, its sensibility, its ability to raise weights, is affected. By comparing the composition of the muscle, recovered after long repose, with that of the muscle tired by exertion, we immediately see that a change has taken place in it. The same may be said of the nerve, which has hitherto offered almost insurmountable obstacles to chemical examination; for how can its tiring be explained except by a chemical change of its mass? All doubt must here be removed on considering the electric change which accompanies every excitation of the nerve, for the differences in the electric tension, which appear in this momentary phenomenon, give distinct evidence of a chemical change.

For a complete understanding of these phenomena, an exact knowledge of the chemical processes in the organism is essential. At present we do not possess this; nevertheless, it is well worth the trouble to examine how far we have advanced in this direction; what requirements are to be fulfilled for further investigations; and in what man-

* Translated for "The Popular Science Monthly" by William Rupp, F. C. S.

ner we are to proceed in order to arrive at the object to be accomplished.

For a series of the most important disclosures, we are indebted to those investigations which have been devoted to the life-processes of the lowest organisms, consisting of single cells. Not that we have here progressed any further than elsewhere, but we have attained the certainty that the most important processes take place in the cells themselves, and that substances are formed which are able to produce powerful chemical changes. The processes to be first considered are those included under the general name of fermentation.

The first known process of fermentation is that which cane-sugar undergoes. A fungus, the so-called yeast, converts the sugar into glucose, and then decomposes this into alcohol and carbonic acid, with the simultaneous formation of small quantities of other products, such as succinic acid, glycerine, etc. The amount of yeast is not increased unless other substances, particularly nitrogenous organic and certain inorganic salts required in building up the body of the cells, are present. From this it appears that various chemical processes take place within the cell, the most striking of which is the decomposition of the sugar. How this takes place is a question which has been largely discussed. From the circumstance that carbonic acid and alcohol are produced in such proportions that the quantities of carbon, hydrogen, and oxygen contained in them are just sufficient to form the sugar, one might suppose that the decomposition is very simple; but, notwithstanding all attempts, the same reaction has never been produced without the aid of yeast. Two hypotheses have been proposed to explain this phenomenon: the one assumes that the yeast-cell contains a ferment which splits the glucose directly into carbonic acid and alcohol, the same as invertin changes cane-sugar into dextrose and lævulose; the other, on the contrary, considers the decomposition of the grape-sugar as an effect of the vital action of the yeast-cells, comparable to the conversion of albumen into carbonic acid, water, and urea in the organism of mammals.

In order to form an opinion of the value of these hypotheses, we will briefly indicate the points of view whence they have been projected. In the first theory consideration is given chiefly to the similarity which the outward appearance of the yeast fermentation has with certain chemical processes, such as the decomposition of sugar by invertin. In both cases the presence of a small amount of yeast or invertin suffices to decompose a comparatively large quantity of sugar, without any apparent change being produced in the yeast or in the invertin. This has given rise to the supposition of the existence of an alcohol ferment in the yeast; a theory which will be verified, when the suspected ferment shall be separated from the yeast, as has already been done with the invertin. All experiments, however, which have been made in this direction have resulted negatively, and hence the

supporters of this hypothesis have been obliged to resort to the theory that the ferment in question is so readily decomposed that it can not be isolated. The other hypothesis is based upon the failure of all attempts to prepare the alcoholic ferment, and therefore assumes that such a ferment does not exist in the yeast, but, that the sugar is decomposed in the yeast-cell in the same way as the albumen is decomposed in the organism of the mammalia. The fact that a small amount of yeast can by degrees decompose a large quantity of sugar is of no more account than that a dog, for instance, can by degrees decompose many times his own weight of albumen. The fundamental difference between the hypotheses, therefore, is, that one assumes the presence of a ferment, while the other denies it.

The former hypothesis was fully justified as long as the nature of yeast and the ferments of the present were unknown ; but, since we know the latter as definite chemical compounds, which are also active without the cell, and do not require this for the development of their activity, we must strictly distinguish between their action and that which we see produced only by the living organism or cell. The latter is not at all to be considered the effect of fermentation, until actual evidence of the presence of a specific ferment is furnished. A simple consideration will show that the decomposition of the sugar, as the result of the vital action of the yeast-cell, may well be compared to the conversion of albumen into carbonic acid, water, and urea, in the higher organisms. If we assume the body of a mammal, a dog for instance, to be reduced to the size of a yeast-cell, without any change in its organization, we would manifestly obtain a microscopic organism, which would act on albumen in the same way that yeast acts on sugar. Its anatomy would be as inaccessible to us as that of the yeast-cell, for the organs would appear to us as dots and threads, similar to the grains which we find in the cells. The changes of the gases in the blood, together with the processes which take place in the intestines or in the liver, and which have so often been made the subject of the most thorough investigations, would be beyond the reach of our methods and we could only determine that these organisms have the power to convert comparatively large quantities of albumen into carbonic acid, water, and urea, with the absorption of oxygen—in short, the process would be similar to that of yeast fermentation. If we had chickens and snakes in the same diminutive state, we should find that they would produce uric acid instead of urea. It would be in vain to attempt to separate from these organisms a ferment which would convert albumen into carbonic acid, water, and urea, or uric acid, with the absorption of oxygen.

The fact that sufficiently reduced dogs and chickens would represent two different ferments shows clearly that the differences which are observed between yeast, the lactic ferment, and the butyric ferment, may be considered due to the inner organization of these most

minute beings. The supposition that one variety of bacteria can produce lactic acid, another butyric acid, a third caproic acid, has recently been stigmatized as "superstition"; but it was forgotten that the cells of the hog's liver produce a different acid from that obtained from the liver of a goose, ox, or man—a fact which evidently is of the same order as that given for the bacteria.

Another point deserves our special attention—the inner organization of the single cells, and the organisms composed of them. Since our present means are insufficient to distinguish this with certainty, we consider the cell or living protoplasm as being without structure. This reasoning is untenable, as it is only supported by the imperfection of our apparatus and methods; on the contrary, other weighty facts are in favor of the presence of such an organization. Above all, it is to be emphasized that within each living cell a number of chemical processes are constantly taking place simultaneously, all of which are necessary for the existence and vitality of the cell. These processes are of so different a nature that it is difficult to believe that they take place within a perfectly homogeneous mass. It seems much more simple and natural to suppose that each of the reactions takes place separately, which could be most readily effected by an internal organization of the cell. The peculiar figures which have been noticed in the division of the cells also speak in favor of this, as do the differences in their exterior forms, which are always governed by the inner organization; the variations in the further development, and particularly the effect on the surroundings, are also in favor of this view. How can we perceive that the bacteria of ordinary putrefaction are comparatively harmless, while the bacteria of splenitis are so destructive, unless we seek the cause in the peculiar inner structure?

Hence the chemical processes within the living cell are of two kinds: those in which ferments take part, and those in which they do not. The ferments are definite chemical compounds, which are able to decompose large quantities of other substances without undergoing any apparent change themselves. The manner in which this takes place is not yet explained, but we have reasons for comparing these processes with others in which a small quantity of one body, e. g., sulphuric acid, gradually converts a large quantity of another, e. g., alcohol, into ether and water. In this case the sulphuric acid acts like a ferment on the alcohol, and the similarity is so striking that it has been attempted to explain both in the same way. Formerly it was supposed that the simple contact of one body with another was in many cases sufficient for complete decomposition, and contact action, produced by the so-called catalytic force, was spoken of. Later it was found that in the above example the sulphuric acid first combines with the alcohol to form ethylsulphuric acid, which is afterward decomposed with a fresh quantity of alcohol into ether and sulphuric acid. Accordingly, the action of every ferment must be considered as consist-

ing of at least two reactions, in the first of which the ferment forms with the substance to be decomposed a compound which is split up in the second with the regeneration of the ferment. This has not been experimentally proved for the real ferments, but it explains these processes so simply and completely that its correctness can not be doubted.

These processes of fermentation have an extraordinary distribution, for not only do the individual living cells produce ferments, but also those which form parts of complicated organisms. This is especially the case with those cells which are often united in enormous quantities to form a larger organ. I will recall the salivary gland, the peptic gland, and the pancreas, whose secretions are exceedingly rich in ferments. This is of the greatest importance for the economy of the animal organism, since it permits a considerable performance with a comparatively small expenditure of means.

I wish to call attention to another important peculiarity of the processes of fermentation—that is, to their sensibility to foreign influences. Some will only take place in a completely neutral or slightly alkaline solution, others only in a slightly acid solution; they all progress most rapidly at a certain temperature, and even slight deviations from the most favorable conditions are sufficient to sensibly retard the action of a ferment or to completely arrest it. The pepsin of the gastric juice acts exclusively in acid solution (best in hydrochloric acid); hence, if the gastric juice contains no free acid or only an organic acid, such as lactic acid, the pepsin will produce no effect on albumen, or only in a slight degree.

Although I have just described this sensibility as a peculiarity of the process of fermentation, it is not to be inferred that it is noticed here exclusively; on the contrary, we find it in all chemical processes, only in a less degree. How many reactions take place only at a given temperature, or at a given degree of concentration? Creatine, for instance, when boiled with baryta-water, is partly decomposed into urea and sarcosine, and partly into ammonia and methylhydantoin; and it is evident that the possibility of splitting up in different directions is increased with the size of the molecule. In the organism a large number of bodies are present which have a very complicated structure, and are therefore readily decomposed. They have an ephemeral existence only, but are, nevertheless, of the greatest importance in the economy of the whole. Most of them are unknown to us, but in some cases they have been successfully isolated. I will only mention glycogen, the discovery of which is several decades old, and the purple of the retina, which has only lately been recognized. All such complicated compounds, having a high molecular weight, are capable of furnishing very different products of decomposition under slightly modified conditions. If, therefore, the decompositions in the organism should always take place in the same manner, the governing conditions must be exceedingly constant. Every product of decomposition, which is

not to be directly excreted, is further employed in the organism, and exerts an influence on the chemical processes taking place, and may therefore produce disturbances in them. An example will explain this: In a large number of mammals the glycocol formed in the organism is not separated by the kidneys under ordinary circumstances; but a quantity of benzoic acid taken with the food is sufficient to fix the glycocol with the formation of hippuric acid, and to separate it in this form. These and similar facts, which can be mentioned in large numbers, have a very important signification, for they give the strongest support to the assertion that the chemical process in the animal body may be considerably changed by apparently slight circumstances. If we accept this, and consider the occurrence of substances still unknown, and present, perhaps, only in very small quantity in the animal organism, we will obtain a hint as to the explanation of effects which many foreign substances produce, though in very small quantities, on the organism. Who does not know the action of strychnia, curarine, prussic acid, and similar poisons?

As our knowledge of these poisons has increased, we have found that they never act on the whole organism, but always on particular organs or groups of organs; these may be the nerves, the muscles, the glands, or only a portion of them. While the curarine paralyzes all voluntary muscles, the heart perceives nothing of its effects; on the other hand, the poison of the fly-agaric—muscarine—paralyzes the heart, but not the voluntary muscles. Strychnia acts only on certain portions of the spinal marrow, opium only on parts of the cerebrum; phenomena which remain completely unintelligible until we attempt to explain them from a chemical point of view, and assume that, at the points accessible to the action of these poisons, there occur, in very small quantities, substances which are of the highest importance to the vital action of the organism, and which are decomposed by them. Of course, chemistry has not yet shown us any essential difference between striped and unstriped muscles, between brain and the spinal marrow, or between the different parts of these organs; but, as the observation of certain lines in the spectrum has led to the discovery of new elements, so may the action of these poisons, at some future time, serve as a guide in searching for these suspected substances.

The chemistry of the animal body is not simply confined to the formation and decomposition of definite chemical compounds; the organism also makes use of certain physical phenomena which are inseparably connected with the chemical, namely, the electric and the thermic. The former take part in the excitation of the nerves, perhaps also in some of the chemical processes; the latter are to be considered as the source of heat in warm-blooded animals as well as of the mechanical force developed by the different muscles. These important facts throw light on the total character of the chemical

processes; for, if the organism is able by their use to keep its own temperature at a higher point than that of its immediate surroundings, and also to develop mechanical force, then, if not all, at least a majority of these processes, are accompanied by a rise of temperature. As is well known, however, the highest temperatures are obtained by combustion—that is, by the combination of other bodies with oxygen. Since oxygen is continually inhaled and consumed by animals during life, we are obliged to consider this as the source of heat and force. We have here a problem which is open to discussion, namely, whether the energy liberated by the combustion was originally contained in the oxygen or in the other substances. It appears as if the latter assumption was generally accepted; at least, statements are often met with, such as, for instance, that coal contains the heat of the sun which has been stored up during thousands of years. Although we can not, at present, with the means at our disposal, definitely solve this problem, it can at least be shown that the statement has little in its favor. The decomposition of carbonic acid by the influence of the light and heat of the sun is effected in such a manner that the carbon is employed in the formation of the compounds of which the plant is built up, while the oxygen escapes into the atmosphere. Now, we know that solids contain the least energy, because it must be supplied to them in the form of heat in order to convert them into the liquid or gaseous state, while, on the contrary, heat must be withdrawn from gases to condense them to liquids or solids. Oxygen is one of the most permanent gases, and must therefore possess an enormous amount of energy, while carbon, on the other hand, being one of the most difficultly diffusible and volatile bodies, can only contain a little energy. This makes it extremely probable that the force of the sun, taken up by the plants, is not stored in their bodies, but in the free oxygen of the atmosphere. Hence the latter is to be considered as the inexhaustible source of power on which man and animals draw, and in the carbon we possess a valuable aid for making this energy, contained in the oxygen, available.

After this digression, let us return to the chemical processes in the animal body. The production of heat and mechanical force, as well as the large quantity of oxygen consumed, indicates that the greater part of these processes must consist of oxidations, and accordingly we find that, among the products of excretion, carbonic acid and water form the principal parts, two bodies which can not be further oxidized. Besides these (to which sulphuric acid and phosphoric acid may be added), other substances are excreted in small quantity, which admit of further oxidation, but which have not suffered it in the organism. I will only mention urea, uric acid, and creatinine. All these compounds are products of chemical action, and the question is raised, How are they produced in the body? to what reactions do they owe their origin? to a single one, or to a whole series? Here we

must confess we have no answer, save in exceptional cases. Wherever matter is found definitely arranged, it is also accompanied by effects dependent upon the arrangement; platinum, zinc, and sulphuric acid, when connected in a proper manner, form a galvanic element and give rise to a galvanic current. Similar relations exist in the animal body; here we also find the constituents in a definite arrangement which we term organization, and by means of which the body has control over such peculiar conditions that we can not, or at best only in rare cases, imitate them in the laboratory, and produce the same reactions as are produced by the body. Although we have been taught, by the celebrated discovery of the artificial production of urea by Wöhler, that the compounds occurring in the organism may also be produced out of the body, this and similar experiments have given no explanation of the manner in which the reaction takes place in the organism. Neither have those experiments been explained in which, after the introduction of certain substances into the body, new compounds, not ordinarily present, are found in the excretions. These investigations have, however, considerably increased our knowledge, by showing beyond a doubt that intermediate products are formed in the body, which are generally directly decomposed, and therefore withdrawn from observation, but which can be fixed by the introduction of foreign material, and so protected from further decomposition. How they are produced or fixed is not explained by these experiments; even if we assume, for instance, that the two components unite, with the elimination of the elements of water, we have not the slightest idea how it is effected. Numerous experiments, in which the amount of substances taken up and excreted by the organism were determined, have given valuable results, but not in regard to the reactions taking place in the body. The chemistry of the living body shows the peculiarity that all reactions take place at the temperature of the body, which is quite low, without the intervention of strong reagents in the ordinary sense. If we wish to produce similar reactions outside of the organism, we generally employ a high temperature and substances which would destroy the organism itself. For instance, to prepare hippuric acid from benzoic acid and glycocol, in the laboratory, it is necessary to heat both for some time to 160°, while in the body it is only necessary to dissolve them in blood, and pass the solution through a kidney, when a combination is effected. A problem is here presented, the solution of which is of the greatest importance to physiological chemistry, and which must, therefore, be attempted with all perseverance. It is no longer sufficient to show that certain substances are changed in the animal body, and give rise to the formation of others, nor does it suffice to make the synthesis which the cell produces, by any means whatever, but we must endeavor to work under similar conditions and with the same means as the body itself. We must make our experiments at the temperature of the body, we must employ no reagents

whose presence would be injurious to the organism, we must also take into consideration that we may not be able to attain our object by a single process, but by a whole series of altogether different processes —only by a most careful observation of all these points can we arrive at results which will allow us to draw conclusions with reference to the corresponding processes in the body.

It may appear remarkable that, in the syntheses which have been made, these conditions were not considered; but it must not be forgotten that a chemist makes a synthesis for its own sake, unconcerned whether he attains his result in the same manner as the organism. He can only attempt the solution of this question when he knows the steps by which the structure is built up. But in this respect we are still far behind, for our knowledge of the chemical properties of the bodies which we find in the organism is still very incomplete. The substances which are most important in the economy of the organism, the albuminoids, notwithstanding the labor and time employed, are very little known, and the same may be said of other substances, such as the bile, the nerve-substance, etc. We do not even know whether the albuminoids and similar compounds have ever been obtained in a pure state; their composition is, therefore, only approximately known; the question, whether the ash which they leave on burning is an essential constituent or an impurity, still remains undecided, and a good method for separating the different members of larger groups is a pious wish. The changes and decompositions of these substances are only known in general; in many cases we know the final but not the intermediate products, which are of the highest importance, as, without doubt, the organism operates with these. Here, above all, it is necessary to throw some light on the obscurity which surrounds this problem, and the necessity will best be shown by an example. If albuminoids are treated with digestive ferments, or with dilute acids, there is at first produced a series of peculiar compounds still similar to the albuminoids, called peptones. If the latter are exposed to the action of strong acids or alkalies, they are finally decomposed into amido acids; at the same time carbonic acid, ammonia, oxalic acid, and other simple compounds, are formed in small quantities. Although completely justified in assuming that the elements of water have been taken up in these processes, it is not positively known in what relation the peptones stand toward the albuminoids; whether the peptones produced from various albuminoids are different or identical, or whether only one or several peptones are produced from each albuminoid; whether they are crystallizable or not; whether the peptones are directly decomposed into amido acids, or whether further intermediate products are formed—in short, we are only beginning those investigations which promise to give the most important results.

Fortunately, the organism also contains more simple compounds, which are well known, and the formation of which can be discovered

more readily. One of the most important of these is urea, and by this we can show that the problem is capable of solution. The high physiological importance of this body is due to the fact that it contains the greatest part of the nitrogen introduced with the food, and removes it from the body. Its composition is very simple, its synthesis has been effected in many ways, and there appears to be no difficulty in explaining its formation in the animal organism. At first it was supposed that it is formed by direct oxidation of the albuminoids, but all attempts to prove this experimentally have failed. Later it was found that nitrogenous bodies, other than albuminoids, particularly the products of decomposition of the same, such as glycocol, asparagin, even ammonia, were converted into urea in the organism ; and, as glycocol and ammonia each contain only one atom of nitrogen, while urea contains two, evidently by synthesis. Accordingly, two hypotheses were proposed to explain the formation of urea in the organism : the one assumed that by the oxidation of the nitrogenous bodies cyanic acid is first formed, which, combining with ammonia, forms ammonium cyanate, and is transformed into urea ; the other, which is principally based on the experiments in which ammonium carbonate is introduced into the organism, assumed a separation of water from this salt, which would of course give urea. But neither of these hypotheses is tenable : for, on the one hand, no chemist has ever obtained cyanic acid by the oxidation of nitrogenous substances under the conditions which are found, or may at any rate be assumed, in the organism ; on the other hand, the ammonium carbonate which is introduced with the food can not be resorbed as such, for it is decomposed by the acid juices of the stomach, neither can this substance be formed in the organism from carbonic acid and ammonia. From the facts which have been observed, however, a third hypothesis may be deduced which is more probable than either of the former. It has been shown that by the oxidation of nitrogenous organic bodies, particularly glycocol, leucine, and tyrosine, in alkaline solution and at a blood-heat, carbonic acid is always formed ; also that, by the union of carbonic acid and ammonia in aqueous solution and in presence of the strongest bases, carbonic acid is produced. We must therefore assume that in the blood or in other parts of the body, wherever nitrogenous compounds are oxidized, carbonic acid is constantly formed. From this salt the formation of urea must take place by the elimination of water, a reaction which has long ago been effected by heating the salt to 140° with absolute alcohol. In the organism this elimination of water must evidently take place in a different manner, and especially at the temperature of the body. This may be effected in two ways : either the water is eliminated as such, or its elements are removed one after another by two different reactions. The latter assumption is the most probable, for it will make it readily perceptible that the reaction takes place in an aqueous solution. If it is asked in what manner the

oxygen and the hydrogen may be removed from the ammonium carbonate, the simplest answer will be that the hydrogen is removed by oxidation and the oxygen by reduction. Experiment has confirmed my expectations. If an aqueous solution of ammonium carbonate is submitted to electrolysis, reversing the current and employing platinum or graphite electrodes, small quantities of urea are formed, which may be isolated and identified as such with certainty. By the evolution of hydrogen and oxygen, alternately at short intervals, the hydrogen is removed by oxygen, and the oxygen is eliminated by hydrogen, and urea remains.

Since both oxidation and reduction are continually taking place in the body, the solution of the question how urea is formed is given, viz., from the ammonium carbonate which is first formed it is produced by further oxidation and reduction.

Here we have urea produced without the body, under conditions which may be assumed to exist within; above all, the temperatures were such as are noted in animals. For this reason this synthesis is particularly adapted to show an acceptable process of the formation of urea in the organism. The question, by what means the organism effects the oxidations and reductions, whether electrolytically or chemically, of course, remains unanswered, but this will also be solved as soon as the processes taking place in the animal system are better known.

This synthesis also distinctly shows what developments physiology is to expect from pure chemistry. The experiments made on animals, by which the conversion of ammonia into urea in the organism was first established, did not teach a single fact which would have indicated that this conversion is the result of two directly opposite processes. This supposition was arrived at, independently of the experiments with animals, by purely chemical considerations, and it was simply necessary to furnish the experimental evidence of their correctness. In this, as in all similar cases, the physiological experiment will disclose the occurrence of synthesis and decompositions; and it will be the province of pure chemistry to discover the ways and means by which the organism produces the results. Both physiological and chemical experiments will have to be jointly and yet independently made, if the chemistry of the living organism is to be established.

Though we must confess that our knowledge of the chemical processes in the animal body is still very incomplete, we must recognize that the investigations made in this direction have given us much information. Though the substances which react on each other are known in the fewest cases, we have obtained hints regarding the manner in which they react. It has been shown why we are obliged to assume that oxidation takes place. We are also acquainted with processes which indicate reduction, others in which decomposition takes place with the assimilation of water, or synthesis with the elimination

of water. Indigo blue is reduced to indigo white, potassium ferricyanide is reduced to the ferrocyanide, potassium bromate and iodate are reduced to bromide and iodide; glycogen is converted into sugar with the assimilation of water, albumen into peptone, and then into amido acids and other products. Hippuric acid is formed, with the elimination of water, from benzoic acid and glycocol.

But we ask in vain: What is it that effects these reductions? how does the pepsin act? how do benzoic acid and glycocol combine? Here is a field in which chemistry must cultivate independently, not as the servant of physiology, for the fruits of the labor will be of equal value to both sciences. Whatever difficulties this problem may produce, we are certain that its solution is within our reach. It was different when, where now we see groups of atoms acting upon each other in a definite manner, irritability or an incomprehensible life-force was permitted to rule. Then the future was without prospect; no vulnerable point seemed exposed for the attack of genius. At present we may say, that which is ponderable can be weighed, and that which proves to be an individual can be isolated. After, however, the analysis is once completed, synthesis will be close at hand.

## A BOTANIST OF THE NINTH CENTURY.*

By C. HARTWICH.

THE contemplation of the progress of science in our days shows us a whole host of zealous investigators bringing stone after stone to raise to a prouder height the structure of knowledge whose richly diversified pillars and towers, seemingly disposed without order, all contribute to the common design. From this view we readily turn to the foundations and basement-stones of the edifice, which, gray and weathered as they seem to be, yet form the basis of the heaven-aspiring building. Our greatest interest is enlisted in the story of the men who, amid the general perversion of manners and contempt for all learning of the middle ages, lived for knowledge in their study-rooms or shut up in silent cloisters. Although they did not make any great discoveries, they still endeavored to keep alive the little flame which yet shone weakly from the intellectual fires of antiquity. Still more fascinating are such views in the case of men who came out into the life of the times, and, with their sharp minds schooled in the philosophy of the ancients, entered actively into the often erratic course of the world, and by word and writing presented themselves undismayed before those in power—here checking the spirit of boundless avarice and wild excess,

* Translated for "The Popular Science Monthly" from "Die Natur."

there defending the oppressed. It is with a man of this kind, the Abbot Rabanus Maurus Magnentius, of Fulda, that we have to do in this essay. After the fall of the Roman Empire the spirit of knowledge became quite extinct, except for a few Greek minds in the Eastern Empire, and in England and Ireland, where gentler manners followed the introduction of the Christian faith and the Latin language, and learning gained a place of refuge; and the knowledge of antiquity spread after Archbishop Theodore and his deacon, Hadrian, founded the school of Canterbury about 680. At last, also, a short but relatively bright period of scientific awakening broke over Central Europe during the reign of Charlemagne, who strove to increase culture and learning in his own land and to introduce them into the countries that he acquired, and for that purpose called learned men to his court, among them Alcuin of England. The cloister schools prospered greatly under Alcuin, and some among them cultivated knowledge with quiet assiduity in the midst of the decline that set in soon after his death. Of these was the cloister of Fulda, to which our Rabanus Maurus was attached. He was born at Mayence, of an old noble family, in 774 or 776, and entered the cloister of Fulda as a *puer oblatus* (destined for the Church) when nine years old. He acquitted himself so well here that the Abbot Ratgar, in 802, sent him to the celebrated Alcuin at Tours to finish his education. Rabanus resided there a year, a favorite pupil of Alcuin's, who, according to the custom of the time, gave him the surname of Maurus. On his return to Fulda, Ratgar appointed him chief of the cloister school, which became famous under him. Soon afterward, however, the abbot changed his mind very suddenly, prohibited studies, and set the monks at manual labor in building churches. A poem written by Rabanus at this time has come down to us, in which he bewails the loss of his books. The monks soon became disgusted with this rude treatment, and complained of Ratgar to the Emperor, who removed him. Eigil was appointed to succeed him, and restored Rabanus, whose intimate friend he was, to his school. Monks came to Fulda from great distances to learn Rabanus's method of teaching, and his scholars were sought for on all sides, so that he soon became known as the first teacher in Germany. Rabanus himself became Abbot of Fulda after Eigil's death in 822.

Under his lead Fulda reached the height of its fame, and no other German cloister, except perhaps Reichenau, could compare with it. He committed the school to the care of his pupil Walafriedus Strabus, author of a work, "De Hortulo," in which twenty-three plants of the author's garden are celebrated in hexameter verses, and in the performance of his duties as abbot himself had but little time to devote to study. Politics claimed much of his attention, and in the contentions which arose for the throne of the empire he defended the cause of Louis against his son, composing in view of the strife a work

on the duties of children to their parents, and afterward supported the pretensions of the claimant, whom he considered the rightful heir, without regard to the probable result of the contest. He laid aside his office in 842 and retired to private life, where he employed his time in the composition of his most important work, "De Universo." He was, however, permitted to remain at this congenial pursuit only till 847, when he was chosen Archbishop of Mayence, and was confirmed by the Emperor Louis, notwithstanding he had been a steadfast adherent of his brother and adversary Lothair. He died in the possession of this office in 856, leaving his books to be divided between his beloved Fulda and St. Alban's monastery at Mayence.

It is now time to estimate the value of the life of Rabanus to science, and especially to botany. In the long period between the irruption of the barbarians and the revival of learning in the fifteenth century, three persons whose labors were independent of each other stand especially prominent—Rabanus Maurus, the Abbess Hildegard of Bingen, and Albertus Magnus. The two latter were superior in originality to the other, but Rabanus was the first German who took the pen and endeavored in his work, "De Universo," to make accessible to his contemporaries what the ancients knew.

Of course, he worked in the spirit of his times, and the theologian is constantly appearing between his lines, endeavoring to keep what he might write in accord with the Holy Scriptures. The principal authority from which he drew was the "Origines" of Isidore of Seville, who himself again drew chiefly from Pliny. His work considers in twenty-two books the following subjects: 1–5. Theology; 6. Man and his parts; 7. Kindred, longevity, marriage, death, monstrosities, and beasts of burden; 8. Other animals; 9. Astronomy and meteorology; 10. Chronology and festivals; 11. Water; 12–14. Geography; 15. Philosophers, poets, sorcerers, and heathen; 16. Languages, civic and military ordinances; 17. Mineralogy; 18. Measures, weights, music, and medicine; 19. Agriculture and plants; 20. War, armor, and the theatre; 21. Arts and trades; 22. Household and farming implements. After the fashion of his time, he gave more attention to the mystic meaning of the objects of nature than to their real properties, and attached the greatest importance to the explanation of names, in which so curious ingenuity was employed as to justify the quoting of a few specimens: Death is called *mors quod amara sit*, or in English because it is bitter; the horse is called *equus*, because only those horses are harnessed together that are alike in size and color (*æquare*); the panther has received that name because he is a friend of all (*πάντων*) animals; the swan is called *olor*, because its feathers are entirely (*ὅλος*) white; the ivy is called *Hedera*, because it is given to kids (*hædis*) for food; the willow is called *Salix* (*quod celeriter saliat*), because it springs up or grows fast. Rabanus adhered quite closely and uncritically to his originals, and it therefore gives us no surprise

to find in his work many of the fables of the ancients. These fables, indeed, endured long after his age, and even as late as the beginning of the seventeenth century editions of Egenolph's formerly very popular book of plants appeared, containing the time-honored stories of the basilisk, griffin, dragon, phœnix, etc., almost in the words of the originals, with each animal represented in a neat woodcut. The botanical part of the work of Rabanus particularly claims our attention. We have examined this, not in the entire work, but in a later compendium of the scientific parts made by Stephen Fellner, at Fulda, who in his review described two hundred and sixteen plants as having been mentioned by Rabanus. I have compared these descriptions with the table of plants described by Isidore of Seville, as given in Meyer's "History of Botany," and have found that the latter has fifty plants more than Rabanus, of which a few, however, are synonyms, and should not be counted to his credit. On the other hand, Rabanus has a few plants that I have not found in Isidore, such as lychnis, lichen, corchorus, fœnum, linum, byssus, farrago. The lichen is, as Fellner declares, *Marchantia polymorpha*. Fœnum is, according to Fellner, *Fœnum græcum*. Fellner identifies byssus with *Gossypium herbaceum*, but translates it in another place by wool, while the text says of the plant: "Byssus is a kind of flax. It is very soft and white; it arises out of the earth, is deprived of its moisture by several protracted processes, and is formed into a handsome cloth." Does not this all agree with asbestus? The account continues, however, "Purple is made of it—a cloth for kings—by dyeing it with the blood of a certain sea-shell animal"; and the ancient name for cotton cloth was generally byssus. Asbestus appears again among the minerals as amianthus; but its application to the manufacture of cloths is not mentioned, except with reference to its incombustible quality, where it is said, "Cloth which is in contact with it resists the fire." Fellner defines farrago as a mixture of various forage-grasses. Some of the plants have not been correctly identified by Fellner. Rabanus in the beginning speaks of the distinction between a tree and a herb, which he regards as consisting only in a difference in age, for a tree, he says, can be developed out of a carefully cultivated herb. In the next chapter he treats of the improvement of trees, of grafting, and budding. The third chapter considers the parts of the tree: the root, which is supposed to reach as deep into the ground as the stem rises above it; the stem, crown, flowers, and fruits, which last he distinguishes as hard-skinned or nut-like, and soft-skinned, like the apple. The fourth chapter relates to the vine. This is the only plant of which a measurably comprehensive description is given, and I will therefore quote from the account, omitting the explanations of the names: "The vine consists of the stock and its shoots. The ends of the branches, the younger shoots, are driven back and forth by the wind. The branches have curled tendrils, by means of which they can cling to the trees,

and thereby put themselves in a condition to resist the attack of the wind, to support the fruits, and to spread themselves out. Those stocks that bear fruit are called *palmites*, the fruitless ones *spadones*. The leaf of the vine serves to protect the branches from cold and heat, and to defend the clusters against injury. The clusters are composed of fat and juicy berries hanging from the comb." The different kinds of fruits, pulse, field-plants, and kitchen-garden vegetables are then described.

The next division treats of the habitat of plants, and shows how each plant prefers a particular kind of soil, whence one will succeed better on one kind of soil, another on a different kind, and neither will do well in a situation badly adapted to it.

Descriptions are afterward given of plants coming under other heads than those above mentioned—those whose fruits are fit for food: the oak, beech, *Phœnix*, *Pomaceæ*, Syrian bean, fig, cherry, mulberry, almond, cherry, *Ceratonia*, pepper (with a recipe for detecting adulteration), *Nardus crocus* (saffron); those which are antidotes to poison: the walnut (*Nux*), radish (*Raphanus*), celery, rue, oleander, germander; medical plants: myrtle, sage, hyacinth, lettuce, thyme, aristolochia, *Prunus*, *Solanum*, mallow, mint, ceterach, saxifrage, dictamus, wormwood, spurge, fennel, ivy, madder, hellebore, heliotrope, thistle, maiden-hair, borage, cinnamon, cyclamen, mandrake, poppy; poisonous plants: hemlock, water-hemlock, hyoscyamus, aconite, *Ocimum*, basil (if one pulls up a handful of basil, he says, all the scorpions in the neighborhood will come around); resin- and gum-bearing plants: the pine (which affords amber), cedar, pistachio, olive, *Docema*, *Populus*, Boswellia, balsam-tree (with a recipe for the detection of adulterations), liquidambar, convolvulus, ferula; timber-trees: spruce, cypress, juniper, persimmon, linden, willow, poplar, oak, larch, aquilaria, box.

The scope, arrangement, and method of treatment of the several parts of the work differ but little from those of the botanical department, which we have thus briefly reviewed.

We close with a return to the figure with which we began. Rabanus is not one of the grand towers of the temple of Science at which posterity will gaze admiringly, nor is he one of the massive buttresses whence numerous shafts and points arise; we should rather compare him to one of the solid stones that are sunk one upon the other into the soft ground to be hardly ever seen again by the eyes of men—one of those who in quiet, busy toil have laid the foundation among the people which now bears so mighty a structure. Such men will always be worthy of our esteem, and should be gratefully remembered by us. Rabanus was one of the most eminent among these men. He was incontestably the most learned man of his times; and he was the first German who ever wrote on science.

# WILD ANIMALS AS MAN'S ASSOCIATES.

By Professor EDWARD S. MORSE.

IT would be a curious study to ascertain at what time certain wild animals came to be associated with man. We do not mean those which have become domesticated, though many of these run back far beyond the historical epoch. By wild animals we mean those which, still continuing in a wild state, build their nests or construct their burrows near, or within, the habitations of man.

The first advances in this direction must have been made by certain members that differed slightly, in their impulses, from others. It might have been the more courageous and intelligent ones, which, not fearing the presence of man, and recognizing the advantage to be gained in the greater abundance of food, selected human habitations as their abiding-places; or it might have been individuals so stupid as not to be aware of the possible danger of man's proximity, and thus unwittingly selected places in or about his dwellings.

The birds that nest in our trees we generally protect through humane or selfish motives, while with the rats, mice, and certain insects, we keep up a perpetual warfare. Yet, that these latter animals survive, indicates that, in spite of this opposition, the favorable conditions must outweigh the adverse ones, otherwise they would soon be exterminated.

A special investigation in regard to birds would be of great interest. The change that has taken place in the habits of birds in forsaking the forests and fields, and building their nests in the trees of towns and villages, must have occurred since the first settlement of this country by Europeans. After the incoming of each species from the wilderness their increase must have been rapid, as the favorable conditions far outbalanced the unfavorable ones. Not only does the bird secure a certain immunity from danger, in the shape of predatory birds like the hawk, but it finds itself in the midst of a plentiful supply of insect-life, which has in turn been lured from the wilderness, and which has developed with frightful rapidity, owing to the dense crops which man raises, and which were not always to be destroyed by every forest fire or persistent drought. Many species have been forced in by the destruction of large tracts of forest, which compelled them to seek other food, or become extinct. The destruction of forest-trees still goes on in this country with criminal celerity, and new insects injurious to vegetation will be added from year to year.

Audubon somewhere remarks that in passing through a dense forest it was the rarest thing to hear the notes of those song-birds most familiar to him, and he could always recognize his approach to a village by the notes of those birds which most commonly frequent our trees and fields. It is known historically when the cave-swallow first

commenced to change its abode from cliffs to the more convenient and protective eaves of barns. Professor A. E. Verrill, in a paper on this subject in the "Proceedings of the Boston Society of Natural History" (vol. ix, page 276), records numerous examples of their first appearance about man's habitations in the East and West, and is inclined to the opinion that, "when this continent was first settled by Europeans, the cliff-swallow inhabited the whole of its breadth wherever there were extensive limestone cliffs suitable for the building of its nests; and that as civilization advanced toward its native haunts, and suitable buildings became accessible to it, it gradually abandoned the cliffs, and, increasing in numbers to a greater extent than before, on account of the protection invariably furnished by man, it gradually spread over New England and the other Northern States, where hitherto there had been no cliffs suited to its wants. In thus extending its range it probably advanced both from the western and from the northeastern parts of the country, both these regions abounding in high limestone cliffs, which are entirely wanting in New England."

A little more humanity on the part of boys, a suppression of the bird-devouring instincts in the cat, and new birds will seek the companionship of man. In Japan, owing to the gentle behavior of the people, the crow has full liberty to go where he likes. As a consequence, the densely populated cities swarm with the noisy fellows. They repay the kindness shown them by acting as scavengers. Every bit of organic matter, which in its decay might pollute the air, is seized upon by the crows and devoured; and thus it is that, by this and other means, the death-rate in these large cities, under the hot sun of latitude 35°, is lower than that of Salem, Massachusetts—for example, in latitude 42°, with its reeking bodies of filthy water. With us the crow has been driven away by constant hard usage, and now it is one of the most wary of birds. In Japan, a crow that has no timidity will, on the whole, get the most food for itself and offspring, and thus stand a better chance of surviving and raising its progeny. Here the same attribute would almost surely lead to its destruction.

It is curious to observe how soon this fear in animals may be excited by the pressure of destructive agencies. More curious still is it to note the fact that insects may be affected by it. I have repeatedly observed that, in places where the common house-flies are undisturbed, individual flies may be caught with ease. At Penikese Island I recall this peculiarity as particularly marked. The movement of the hand in the effort to catch them was invariably too quick. A friend of mine has observed the same peculiarity concerning the house-flies in a country church. They could easily be touched with the finger. It is plainly obvious that the alert flies would be the ones to escape, and, thus surviving, would perpetuate their peculiarities, while the stupid ones would be the first to perish in any attempt to get rid of them. The house-rat under the same selective action has, by continual survival from the

quick-witted ones, become synonymous with all that is crafty and cunning.

We commenced this article mainly to call attention to some facts concerning a certain kind of ant, which must have attracted the notice of others before. It is difficult, at first, to see what special advantages can offer to the little yellow ants that persistently, year after year, construct their burrows under our brick pavements, and use these thoroughfares for their promenades and hunting-grounds. One would consider that such regions would be almost the last places these intelligent little insects would select. Many of them must be crushed daily beneath our feet, and their little hillocks and annular tumuli trod upon or swept away. Side-walks which are much traveled on are often selected by these industrious and courageous little fellows, and here they burrow beneath the bricks, and heap up their moles undaunted by the frequent demolition of their work, and the death of many of their comrades. It is obvious that the advantages must outweigh the disadvantages, otherwise the ants could not long survive, and continue their work, as they do from year to year.

We know well enough the unfavorable conditions to which they are subjected: the crushing steps of busy feet; the wheels of boys' velocipedes, and children's hoops; the sweeping-broom, a very scourge of destruction; deluges from the garden-pipe, which to them must be Noachian, and the occasional trailing of a long skirt, with the devastating effect of a typhoon and sirocco rolled into one. All these must invariably destroy many lives and demolish many an earth-work.

Among the conditions that these ants require for their perpetuation and increase are, first, soil in which they can easily burrow their nests and galleries; second, substances which may be heated by the sun, and beneath which they may bring their pupæ, or partially developed offspring, in order to hasten their more rapid development. It is said that colonies of ants have constructed their nests in or near fire-places that they might avail themselves of the artificially heated bricks of the hearth for this purpose. In pastures ants often construct their galleries beneath large stones, and bring their pupæ up from the burrows below, placing them just beneath the stone which has been heated by the sun, and which retains the heat for a considerable time after the sun sets. It is a common experience in turning over stones in the pastures to find the galleries just beneath densely crowded with pupæ, and when the ants are surprised in this way they show great solicitude in their efforts to remove the pupæ to a place of safety. It is astonishing to see how quickly many hundreds of pupæ are removed to the burrows below. In using the brick walks of cities, the ants find the most suitable conditions for their burrows, as it is customary to bed the bricks in a layer of sifted gravel, and the ants, in mining into this material, are not interrupted by the obstacles they would naturally encounter in other deposits. The bricks

become heated with every day of sunshine, and thus the ants find all the conditions necessary for the rapid development of their pupæ.

Of equal importance is the fact that an abundant supply of food is ready at hand in their hunting-grounds—food already slaughtered for them—so that they are saved the time and trouble of overcoming and destroying their prey. Not only are they certain to secure the caterpillars, worms, and a variety of insects which are crushed by passing feet, but also the crumbs dropped by children, or swept from the houses, as well as the banana- and orange-peel, peach- and cherry-stones, and the like, which often litter the sidewalk. Here, then, is a variety of food to supply their tastes, and, when not otherwise engaged, they may be seen tearing off the fruit-fibers from some cherry-stone or apple-core, or tugging away busily at some maimed or crushed insect or caterpillar. In selecting proper places to build their nests, they choose, if possible, those which are neither damp nor liable to inundation. If the sidewalk, they secure a level territory from which the rain runs away as fast as it falls. With all these favorable conditions they manage to survive and flourish, despite the frequent choking up of their passage-ways, and the many deaths, by crushing, of their workers.

Thus it is that what seems to us a very precarious and unfavorable region in which to live, the ants continue to occupy from year to year, and to increase in numbers. The struggle for existence is well illustrated by this example, and it would be interesting to know just how many footsteps a day they can endure and yet survive. A densely traveled thoroughfare will be found to support but very few ants' nests, and these are upon its borders, while one less traveled, if it is comparatively dry and not heavily shaded by trees, will be found infested with them.

The mud-wasp which plasters its cells under the roofs of barns, garrets, and sheds in Northern New England, parallels the eaves-swallow which constructs its mud-nests beneath the eaves of barns. Here the brighter individuals show great judgment in selecting places removed from leaks in the roofs. We have observed many remarkable selections of building-sites among these insects, and doubtless numerous interesting facts await the patient study of these curious animals.

## THE PHILADELPHIA ACADEMY.

By J. S. KINGSLEY.

IN a Canadian journal devoted to science there appeared, not long ago, an article entitled "The First and most Profound of Savants," and old Father Adam was intended by this superlative title, for did he not give to every animal a name? What a pity it is that these Adam-

itic appellatives have not descended to our day, since for years naturalists have been inflicting long Latin cognomens on all animals and plants coming under their observation, and it would almost seem as if the supply of names would be exhausted long before the things to be named!

Ever since the time of Adam men have enjoyed a contemplation of the created things which surround them, and have formed collections of minerals, plants, or animals, varying in size from the few "curios" on the mantel-piece of a back-country parlor to that most wonderful display contained in the British Museum. Our records of the museums of antiquity are very meager, and but little can be told concerning them. Noah's collection in the ark can hardly be considered in this connection, as it was formed with an entirely different end in view. Solomon possibly had a collection. The temple of the oracle at Delphos had many curiosities brought as votive offerings from foreign lands. Apollonius saw with surprise in India trees bearing the different kinds of nuts he had before seen in the temples of Greece. The museum at Alexandria contained the largest collection of books in antiquity, but whether it contained productions of nature is not known. Alexander the Great commanded all sailors and traders to bring the peculiar productions of the countries they visited to Aristotle; Apuleius made a collection of the fossils of the Gætulian Alps; while the Emperor Augustus had a large cabinet of curiosities from all parts of the then known world.

One reason why the ancients were deficient in museums was the lack of efficient methods of preserving the various forms of life: covering a body with wax or honey was not the best manner imaginable of rendering an object either interesting or instructive; and so it was that not until the discovery of alcohol and the manufacture of glass bottles that museums became of much importance. Another fact that also had much to do with the entire absence of any collection from the third until the sixteenth centuries was that all studies of nature were regarded as strongly savoring of infidelity, and were therefore to be discountenanced. So it was that not until the revival of letters were museums known in the Christian era.

In the seventeenth and eighteenth centuries every prince of Europe felt it incumbent upon him to be a patron of learning, and, with the object of advancing the knowledge of nature, formed a cabinet in which were mingled in the most absurd manner Chinese mermaids, pebbles from the Holy Land, birds from the Orient, and coins from ancient Rome. Every prince also deemed it his duty to employ some scrivener to write, in that quality of Latin which has justly been styled "piggish," descriptions of the various curiosities thus brought together; and these lucubrations, embracing fact and fiction curiously mingled, were published with all sincerity in ponderous tomes illustrated with rude figures which, by a severe strain of the imagination,

might be supposed to resemble something, but generally not the thing intended. But with the gradual intellectual development of the world these collections became more and more systematic and useful, and the resulting publications acquired a higher character, discarding fiction and old wives' tales, and presenting only facts acquired by observation. About the middle of the last century arose a man, Carl Linné (or Carolus Linnæus), abundantly blessed with the powers of generalization, who, by introducing system into the previous chaotic mass, placed the study of nature on a firm foundation; and from his time the progress of natural science has been astonishing. Naturalists immediately arose in all parts of the civilized globe, collectors were sent to those parts which were so unfortunate as not to be civilized, and soon almost every city in Europe boasted a museum.

America, however, was a young country, and, between its wars with the Indians and with England, its settlers had but little time to devote to study. An occasional naturalist from Europe landed on its shores to explore its wonders, and isolated persons made collections, which were duly forwarded to the Old World. It was not until some time after the Revolution that America possessed a single museum. Probably the first was Peale's Museum, in Philadelphia, which was established in the last century, and where might have been seen side by side a mastodon and a machine for producing perpetual motion. The Museum of the East India Marine Society, at Salem, Massachusetts, was begun but a few years later, and until a dozen years ago retained many of the characteristics of those comparatively primitive times.

Leaving these early museums, with their lack of system, the first which was strictly scientific was that of the Philadelphia Academy of Natural Sciences, and to give a brief account of that institution is the object of the present paper.

Before the War of 1812 Philadelphia was the only city in the Union which could make the slightest pretensions to being a scientific center; the Bartons, Bartrams, and Muhlenberg, were enthusiastic botanists; William Maclure had just published his "Geology of the United States"; and Alexander Wilson had just begun his "American Ornithology," which was left unfinished at the author's death. During the year 1812 several young men occasionally met for the purpose of mutual amusement and instruction, and at one of these meetings the project of a scientific society was proposed, discussed, and finally (January 12, 1812) Drs. Gerard Troost and C. M. Mann, and Messrs. Jacob Gilliams, John Shinn, N. D. Parmentier, and John Speakman, met at the house of the latter and instituted the Academy of Natural Sciences of Philadelphia. Thomas Say joined them a few weeks later, but has always been regarded as one of the founders.

Dr. Troost was a native of Holland, and for a time was a pupil of the celebrated mineralogist, the Abbé Haüy. Subsequently he was sent by Louis Bonaparte, then King of Holland, to Java as naturalist,

but the ship on which he took passage was captured by a French privateer, and he was made a prisoner. On regaining his liberty he started for the New World, landing in Philadelphia in 1810, and soon engaged in the manufacture of alum. He accompanied Maclure to New Harmony (of which more anon), and, on the failure of the community, became professor in the university at Nashville, and subsequently was appointed State Geologist of Tennessee, a position he held until a year before his death, which occurred in 1850.

William Maclure, the pioneer American geologist, was a Scotchman by birth. He came early in life to Philadelphia, where by a successful mercantile life he acquired an ample fortune. He spent several years in travel, hammer in hand, exploring every State and Territory from the Gulf of St. Lawrence to Florida. The results of these excursions were embodied in the first paper on American geology ever published, which appeared in the "Transactions of the American Philosophical Society" in 1809. At the time of the foundation of the Academy he was on a geological trip, but as soon as he returned he became a member, and from that time until his death retained a lively interest in its welfare and prosperity. He gave largely of books, specimens, and money, his donations of the former amounting to over 5,000 volumes, and of the latter more than $25,000. Mr. Maclure was eminently a philanthropist, but, like many others of similar disposition, was rather visionary. He entertained the idea of educating all mankind, of establishing a university where all human knowledge should be taught, and was also a firm believer in, and strong advocate of, the "community system"; and, with these ideas predominant, he persuaded Troost, Say, and Lesueur to accompany him to New Harmony, Indiana, where his Utopian plans were to be carried into execution. But man is liable to err, and internal dissensions and legal difficulties soon caused the community to break up. Maclure died shortly after in Mexico.

Thomas Say was born in Philadelphia in 1787, and in his early years attended a private school some miles out of the city, where, owing to the inefficiency of his instructors, he acquired but little except a most intense dislike to all polite literature. His father, seeing that his tastes were anything but literary, apprenticed him to an apothecary, and afterward he entered into partnership with John Speakman in the drug-business. This partnership was peculiar in the disinterestedness with which it was conducted. Speakman alone attended to the business, that his partner might devote all his time to the pursuit of science. But the firm of Speakman and Say came to an untimely end by indorsing for unfortunate friends. After the failure, Say took up his quarters in the rooms of the society, making his bed beneath the skeleton of a horse, and living for several years on bread and milk, with an occasional chop or egg, during which time his food did not cost on the average twelve cents a day. Say, as has been stated, accompanied

Maclure to New Harmony, where he remained as agent after the failure, until his death in 1827. Thomas Say was the father of American entomology, and his papers on other departments of zoölogy were numerous and valuable.

The first meetings of the Academy were held at the house of Mr. Speakman, and afterward a few occurred in a public-house known as the "Mercers' Cake-Shop," but, as custom demanded that all frequenting the place should become patrons, and fearing that the society would forsake the paths of science and degenerate into a gastronomic club, more secluded quarters were secured over a millinery-store on Second Street, near Race, and there was formed the nucleus of the present large library and collections. Dr. John Barnes was the first member elected, and it is related that, on the occasion of his first taking his seat as a member, the seven founders, who had constituted themselves a committee of management, withdrew to transact some business, leaving him alone to constitute a meeting of the Academy. In the first year of its existence the society came in possession of the Seybert collection of minerals, at a cost of $750.

The growth of the collections soon demanded increased accommodations, and a larger room was hired, on the opposite side of the street, which was occupied until August, 1815, when the society moved into a building erected for them on Arch Street, near Second. In 1817 a charter was obtained, and the same year the publication of a journal containing the scientific papers presented to the Academy was begun. In 1826 the library and museum had again outgrown their quarters, and the Swedenborgian church, at the corner of Twelfth and Sansom Streets, was purchased and adapted to the needs of the society at a cost of about $6,000. Several members opposed the purchase of this property, and Mr. Maclure, when called upon to subscribe, at first declined, giving as a reason his belief that the "community system" would prevail, Philadelphia be deserted, and that those who lived long enough would "see the foxes looking out of the windows." He eventually gave several hundred dollars. This building was occupied by the Academy fourteen years, when a return of the old trouble, a lack of room, necessitated a new building, which was accordingly erected on the corner of Broad and Sansom Streets, and first occupied in February, 1840. Seven years later it was found necessary to enlarge the building, to accommodate the Duc di Rivoli collection of birds, numbering 12,000 specimens, which were presented by Dr. Wilson, who also bore the expense of the enlargement. The building was again enlarged in 1854–'55, the expense being borne by subscription. In 1868 a lot was purchased on Nineteenth, Race, and Cherry Streets, containing more than an acre, at a cost of $65,000. The corner-stone of a new building was laid with appropriate ceremonies October 30, 1872. The society held their first meeting in this edifice January 11, 1876.

The portion of the building at present erected and occupied by the

Academy forms not quite a third of the contemplated structure. It is built in what is called the collegiate-Gothic style of architecture, of a green serpentine, with light-brown sandstone trimmings. This wing is one hundred and eighty-six feet long and seventy-five feet broad. The basement is devoted to storage, with rooms for a taxidermist and a printing-office. On the ground-floor and its galleries are the library, studies, rooms for artists, a bindery, a smoking-room, the herbarium, and collections of insects and microscopes and microscopic slides. The library is one hundred and thirty feet long and thirty feet wide between the ends of the cases, with a gallery at the height of ten feet, and contains the largest collection of works on natural history—over 26,000 volumes—in America. The floor of the library is used for the meetings of the Academy, and will seat over four hundred people. From the entrance on Race Street, two short flights of stairs bring one to the museum, a hall extending the whole length and width of the building, with two wide galleries, giving a floor-space of more than three fifths of an acre. The whole is fairly lighted by windows in the sides and by a lantern sky-light eighty feet in length. The whole building is fire-proof, is heated throughout by steam, and was erected at a cost of nearly a quarter of a million dollars.

A description of a museum is by no means an easy task, even in the case of a small collection; but, when the number of specimens is as large as in the present instance, it is only possible to enumerate a very small proportion of the many treasures. On entering the hall, the visitor sees almost immediately in front of him, towering to a height of fifteen feet, a skeleton of *Hadrosaurus*, a kangaroo-like reptile from the greensand of New Jersey; around this are assembled a polar bear, a rhinoceros-skeleton, two or three whale-skeletons, the frame of a gorilla, a stuffed giraffe, and another in the condition Sydney Smith wished to be in in hot weather, divested of flesh, and sitting, or rather standing, in its bones. The table-cases and some of the upright cases near by are filled with fossils, while in the wall-cases on the south side of the building is displayed the ghastly collection of skulls, about twelve hundred in number, which is not excelled anywhere in the world. The upright cases on the north are occupied by the mammals, while the wall-cases contain the fishes. Two flights of stairs at opposite ends of the hall give access to the galleries, the railing-cases of which are occupied by the minerals. The first gallery is the most attractive to the ordinary visitor, as almost every case is devoted to the enormous collection of birds, over 30,000 stuffed specimens being displayed, while many thousand skins are packed away in drawers. Of this large number, 27,000 specimens were the gift of one person, the late Dr. T. B. Wilson, of Philadelphia. The collection is the third largest in the world, being excelled only by that of the British Museum and one in Vienna. Besides the collection of the Duc di Rivoli, mentioned before, it contains the collection of 2,000 specimens for-

merly owned by the distinguished ornithologist, John Gould, and which formed the basis of his magnificent work on the birds of Australia. Here may be seen a specimen of the great auk, of which only two other specimens exist in America, and less than a dozen in the whole world. There is also an egg of the same bird, there being but one more in this country. And, while mentioning the eggs, we would say that the collection of these fragile objects is not excelled in Europe, embracing as it does 5,000 specimens, representing 1,323 identified species. The crabs, lobsters, and shrimps occupy cases beneath the windows of the galleries, over 1,000 different kinds being exhibited. On the second gallery are the shells, the largest collection in the world, both in species and in specimens. The largest single donation to this department was the collection of George W. Tryon, Jr., of over 100,000 specimens, illustrating over 10,000 species. Of the fresh-water mussels alone, 783 different kinds are on exhibition. The collections of star-fishes, sea-urchins, and corals are on this floor, but, though large, are excelled by those of several institutions in the United States.

Owing to the destructive action of light, the insects are not displayed, but are kept in two rooms connected with the library. Over 70,000 different species and hundreds of thousands of specimens represent the insect world. The herbarium is also very extensive, and occupies two rooms opposite to those devoted to insects.

The Academy holds its regular meetings every Tuesday evening, at which times papers giving an account of original investigations are presented, and remarks are made on various scientific subjects. Besides these regular meetings, members who are interested in special subjects have associated themselves in "sections," which meet at stated intervals. Four of these sections now exist, devoted respectively to microscopy, conchology, botany, and entomology. The Academy maintains two series of publications, while the conchological and entomological sections have at times published their scientific proceedings separately. The total publications of the Academy and its sections numbered, July, 1876, 3,681 pages and 404 plates quarto, and 20,752 pages and 499 plates octavo.

This magnificent museum and library is a monument to the generosity of comparatively few of the citizens of the "City of Brotherly Love." With the exception of exemption from taxation, not one cent has the Academy had from city or State. General funds it has none, its running expenses being paid by the annual dues of the members and the proceeds of a small admission-fee (ten cents) to the museum. Its special funds realize about $600 a year for publication, and $1,800 for the library. There is also a scholarship fund which pays two or three students twenty dollars a month while pursuing studies at the Academy.

The object of this rather statistical sketch is not only to give an account of one of the most prominent scientific organizations in the

country, but also to encourage the people of other cities to do likewise. There is not a place of 20,000 inhabitants in the country which should not be able to support a scientific society, and, though time would be required to accumulate such a library and such collections as those owned by the Philadelphia Academy, still no one should be discouraged, since no beginning could be more humble than the one we have described. Science is becoming every day more prominent in our country, and our colleges are rapidly giving it that preference which has been accorded to the dead languages in the past, and this is a change for the better, for it is a fact that the American mind is a practical one. The number of young men who attend our colleges to-day is relatively smaller than it was a hundred years ago; and even of college students a large proportion become farmers or physicians, or follow mining, manufacturing, or mercantile pursuits, and to them science is of far more practical value than the wars of Cæsar or the "Birds" of Aristophanes. The field of science is an expensive and difficult one for the isolated student to explore. Specimens are requisite and books are necessary, and these are most readily obtained by a co-operation of all who are interested, and this very co-operation for this purpose is the foundation of all scientific societies.

## A LITTLE MATTER.

By A. E. OUTERBRIDGE, Jr.

THE original investigator in Nature's domains may not inaptly be likened to a pioneer who penetrates the primeval forest, and by the aid of his keen hatchet hews down the obstructions, marking out first a narrow path in the wilderness until he reaches a favorable camping-ground. He then clears a space, admitting sunlight and air; meanwhile, he is perhaps unconscious of, or indifferent to, the approaches of other adventurers, until, little by little, the clearings encroach upon each other; cultivated fields, orchards, vineyards, and gardens appear; the face of the landscape changes, and its every aspect becomes familiar, so that we cease to wonder at its sometimes strange and novel features.

This analogy is not a mere fancy; all the advances in scientific knowledge have been made in little detachments. Narrow lines of investigation have been projected and explored by patient toilers who dig out a few roots here and there, which are carefully garnered until their genus can be determined by further study. In this way, separate facts are being constantly stored up, to be collated and classified at a proper time.

The ideas which have prevailed in the past, in regard to the nature

of the ultimate particles of matter out of which worlds are formed, reveal the speculative tendency as well as the intellectual status of the human mind in different epochs of the history of civilization. The present era might be designated as an interrogatory age, for the evident tendency is to question eagerly, to accept nothing on the evidence of tradition, and but little, comparatively, on the merits of faith.

Plausible explanations of various phenomena have so often been accepted with confidence, only to be overthrown and supplanted by others equally unstable, that the mind has become suspicious, and demands the most rigid physical tests to corroborate new theories. The experimental feature of scientific study has thus attained an importance and perfection never before approached, and this cause largely contributes to popularize even the most abstruse subject of inquiry. The object of this brief paper is to present, albeit in a feeble manner, the claims of one of these little paths of knowledge to the exploration of the general reader, who, like the summer tourist, sometimes prefers to leave the beaten track, to enjoy the novelty of a rougher road.

The learned judge who, being requested to define the distinction between mind and matter, replied, "One is no matter, the other—never mind," solved the difficulty in a terse if not very satisfactory or exhaustive way. The question, "What is matter?" is one that has exercised the intellects of the profoundest thinkers in all ages, and the conundrum is, apparently, as far from being definitely answered in this nineteenth century as in the classic days of the Greek philosophers. It would seem, indeed, that the modern views of matter, based upon strictly scientific data and mathematical reasoning, have approached very closely to those propounded by the Attic philosophers, which were evolved purely from the inner consciousness of the poetic sages, the ancient theories being rather expressions of sentiment or feeling than of observed realities or facts. We may find a parallelism to this in the grand musical compositions of the old masters: knowing nothing of the modern science of music or the laws of acoustics, they felt and recorded harmonious combinations which are now shown by analysis to conform to most rigid mathematical laws. The poetical fancies of Lucretius on "The Nature of Things," which have been preserved to us through a lapse of two thousand years, will receive new interest in the light of modern scientific revelation.

The delicacy of the apparatus devised by physicists and the refinement of experimental demonstration rendered possible thereby are among the greatest marvels of this wonderful age. The physicist is pushing his researches into paths which but a few years since were thought to be for ever hidden somewhere in the vast realm of the "unknowable," and the boundary line between so-called physical and metaphysical science is continually narrowing. Just as the skilled mountaineer or the aëronaut ascends gradually into the rarefied upper atmosphere, in order that the system may accommodate itself to its

new environment, so the philosopher has advanced, step by step, until he seems almost to have grasped the ultimate particles which constitute the physical basis of the universe, and to have rendered visible to mortal unaided eyes particles of matter which are not only invisible by the aid of the most powerful microscope, but are too infinitesimal even for the mind's eye to conceive.

When that marvelous little instrument called the spectroscope was devised, it seemed that man had invaded fairy-land and stolen "a trap to catch a sunbeam," for such it is, in very truth: not only does it catch the dancing sheaf of light, but spreads it out into a band of exquisite colors and exhibits to our fascinated gaze Nature's palette of purest tints, out of which is woven the whole fabric of the gorgeous sunset, the variegated flowers, the bright plumage of the birds, the iridescence of mother-of-pearl, the sparkle and hue of gems, and, indeed, every variety of color in nature or in art.

But this little instrument is still more wonderful, for it combines with its qualities of a trap the advantages of a balance which we may suppose is fine enough for the most fastidious fairy to weigh the nectar distilled in the dew-drop, or other delicacy of the season.

Our ideas of weight and size are purely relative, and that which seems a small or light object, from one point of view, may become large and heavy by a different comparison. To most of us, perhaps, a "grain-weight" suggests a little thing; we know that the apothecary and a few other small dealers split up the grain into halves, quarters, tenths, and perhaps even hundredths, but then we regard them as homœopathic visionaries and laugh at their absurd little pellets; yet, strange to say, there is a vanishing-point in our minds, which, if an object is small enough to pass, it becomes larger and more important by reason of our astonishment and wonder at its minuteness: the most ordinary specimen under the microscope is an evidence of this, but when we realize that the ability of the spectroscope to reveal small particles of matter begins where the finest microscope searches with its highest power in vain, that the grain of matter may be divided, not merely into hundredths, or thousandths, or tens of thousandths, but into millionths and tens of millionths, and that a single one of these particles may be readily detected by this little searcher and held up for our inspection, our wonder and amazement enhance our respect for its occult powers. The astronomer tells us that a comet often throws out a tail longer than the distance between the earth and the sun, and broad in proportion; yet the matter forming this tail is so attenuated that, if properly compressed, a gentleman's portmanteau, possibly his snuff-box, might take it in.* Yet we have merely to point this little tell-tale at the comet, and, presto! we know what the matter is. Think of it! Not merely can we grasp infinitesimal particles at our hand, but we may sweep the firmament, gather up the star-dust and tell its composition.

* See "Fragments of Science," Tyndall, p. 444.

But we have not yet reached the end of our excursion; indeed, we have only entered the threshold of the scientist's sanctum, and the wonders of the arcanum eclipse those of the portico. That mysterious agency or force called electricity has been utilized, not merely for the benefit of bulls and bears, or for hundreds of utilitarian purposes with which we are familiarized every day, but it has been used as a fairy-finger to probe Nature's hidden structure, and, as it were, enable us to *feel* what the spectroscope has revealed to sight.

Then, again, appliances for obtaining little samples of "stellar space" in the interior of glass bulbs—bottled vacuity—which we may examine at our pleasure, are in themselves curious. Think of a bulb about the size of a cricket-ball containing only one ten-millionth part of one atmosphere, and that part being subdivided into millions and millions and millions of individual portions, and these particles being captured and made to do visible, tangible work; think of a miniature engine with a propeller-wheel being made to revolve and a little railway run by projecting these minute particles against the driving-wheel; think of a piece of refractory metal like platinum being so terribly battered by hitting it in rapid succession with a charge of these little molecules that it is made to cry out in fervent heat, to glow with a bright light, and, if this molecular bombardment is continued, even to melt before it like wax; think of the commonest and most uninteresting materials, like burned oyster-shells, being made to shine with a luminosity rivaling the "great carbuncle," or the famous "Kohinoor"; of little pieces of glass outvying the finest emeralds, rubies, and sapphires, when under this marvelous influence—then, we will be ready to admit that, while we work-a-day, matter-of-fact people may not understand the motive that induces the original investigator to plod on in his narrow path, continually prying into some seemingly trivial corner of Nature's vast store-house of knowledge, we can nevertheless appreciate and enjoy the beautiful results which modern Science has to offer as rewards to her votaries, and we can not too greatly venerate the genius of those who could conceive the possibility of such results, and possess the ability to produce them.

## VIBRATION OF ROCKS IN PATAPSCO VALLEY, MARYLAND.

By FREDERIC GARRETSON, M. D.

THE valley of the Patapsco River, through which the Baltimore and Ohio Railroad passes, presents many interesting subjects to the student of physics and of geology. After passing the junction of the Washington branch at the Relay House, eight miles west of

Baltimore, the alluvial plain gives place to a narrow valley with steep and wooded hills on either side, and walled with conglomerate or metamorphic rocks. Above Ilchester, a few miles farther up the valley, begin the beds of solid granite, which are excavated by several quarries near Ellicott City, fifteen miles from Baltimore. It is worthy of observation that these granite beds are replaced, a few miles above, by separate rocks composed of the ingredients of the granite, or resulting from their decomposition. In the cuttings of the railroad five miles above Ellicott City, large masses of nearly pure silica are found, and in the same vicinity feldspar is abundant. The mica is sufficiently stratified to furnish a supply worth working for market; and asbestos, in more or less advanced stages of formation, is quarried to some extent for purposes not requiring a perfect fibrous structure. Kaolin of very good quality is found, but has as yet been little worked. These rocks will at some future time well repay exploration.

The object of the present paper is to record a phenomenon observed at Ellicott City, which lies in a narrow and deep valley, nearly at a right angle to the Patapsco, which is here a stream of some sixty yards in width, flowing very rapidly over a broken and rocky bed. About an eighth of a mile below the town, the turbulent stream enters a straight channel with a comparatively even bottom, and flows for nearly half a mile with steady current and a depth of three to six feet. The river is then checked by the dam of a large mill, and presents a fall of about ten feet, with a sheet of water seldom more than six inches in depth pouring over the edge of the dam.

The stream is here over sixty yards wide, and the body of falling water produces a sound which can not be heard more than four hundred yards below, or half that distance above the dam. The impact of the fall is so trifling that it causes no perceptible vibration in the immediate vicinity. Yet, in the valley where Ellicott City is built, more than half a mile above the fall, the houses on either hill-side, which have foundations deep enough to reach the granite bed-rock, are subject to occasional vibrations which shake their walls and cause a continuous rattling of the windows. This effect has, of course, been ascribed by the people, in an indefinite way, to the river, but it was some time before I collected the physical data for the explanation which is here offered.

In making the investigation, it was observed that the current of the river above and near the town was broken by rocks, and, although rapid, could produce no rhythmic vibrations because of the irregularity of its impacts. The apparently quiet flow of the stream below did not seem to offer any solution of the problem, and the fall of water over the dam had evidently a very trifling force of impact. But a more careful observation of this little water-fall convinced me that it was the motive power. First, a peculiar shimmer in the reflection of light from the edge of the dam, and on nearer approach a distinct

rhythm in the movement of the falling water, were observed. This was found to occur only at certain times. If the river was either too high or too low, the water poured over the dam with regular and uniform motion and sound; when the vibration of the houses occurred, the pulsatory movement of the falling water was also noticed.

The vibrations of the water were estimated at eight or ten per second, or about half of the number required to give the lowest continuous sound. These facts being established, it still remained to account for the enormous mechanical effect necessary to produce the vibration of distant buildings.

The long stretch of steadily flowing water above the dam, whose sloping edge only partly arrested its course, suggested the divided current of air thrown into the pipe of an organ. And, as the small column of air in the pipe, when thrown into vibration, is known to produce in some cases a perceptible tremor in the massive walls of a church, it is probable that a column of water half a mile in length, when in rhythmic vibration, would have a mechanical effect in proportion to its mass. But, in order that such vibration of a considerable body of water should be produced, a peculiar combination of physical conditions must exist, and this I have never observed in any other place.

Of course, the fall of such masses of water as pour over Niagara and other great cataracts will cause a tremor of the earth to a certain distance. But this is due to the simple mechanical force of impact, and is in relation to that force only. The phenomenon which I have described is intermittent, and that fact points to the conclusion that it is due to a definite relation between the vibrations of the river and what may be called the key-note of the bed-rock over which it flows.

The distance to which such motion may be transmitted will, of course, depend upon the mass of water in vibration. The direction will depend upon the continuity of the underlying rock. Where this is broken by seams, the vibrations will cease, and therefore the line of these remarkable tremors affords an indication of the structure of the granite bed which is the basis of the picturesque hills around Ellicott City.

## M. SAINTE-CLAIRE DEVILLE.

HENRI-ÉTIENNE SAINTE-CLAIRE DEVILLE, one of the most distinguished of French chemists, was born at St. Thomas, in the Antilles, of French parents, March 11, 1818, and died at Boulogne-sur-Seine on the first day of July last. He went to France while still a boy, with his brother, Charles Deville, the meteorologist, and had his attention drawn early in his career in school to chemical studies, which were then enjoying high credit under the brilliant results

of the investigations of Thénard, Gay-Lussac, Chevreul, Dumas, Balard, and Pelouse. It is said that he hesitated at first between science and music, but was finally attracted to chemistry by the lectures of Dumas; and, on leaving college, he constructed a laboratory at his own expense, and pursued his researches without either master or pupils for nearly nine years. He was not more than twenty years old before he marked his place in science by an original work, the scale of which he enlarged in the following years, exhibiting in it so many proofs of an inventive and clear mind that he was sent to Besançon to organize the newly-created faculty of sciences in that city, and became its dean—at the age of twenty-six years. Here, on invitation of the municipal council, he undertook the analysis of the waters of the river Doubs, and of the numerous springs around the town. Applying new and more exact methods, he ascertained the presence of nitrates and silicates in all the waters—facts which were afterward confirmed by Boussingault, and shown by him to have an important bearing on agriculture. This analytical talent out of the usual line, says M. Pasteur in his funeral eulogy, which was one of the features of Deville's genius, never abandoned him; and, "if you review the field of his persevering labor as a whole, you will find it marked at every step by evidences of a passionate seeking for the most perfect analytical methods. That rigor of analysis, which is the probity of the chemist, . . . Deville communicated to all his pupils, and it may be seen to shine in the labors of all those whom he inspired—of Debray, Troost, Fouqué, Grandeau, Hautefeuille, Gemez, Lechartier, and many others."

In 1851, when thirty-three years old, Deville succeeded Balard in the chair of Chemistry in the Higher Normal School in Paris, where he worked at tasks which have led to the enrichment of wealthy manufacturers, and with an ardor which made the laboratory of this institution a central point of chemical investigation for all Europe as well as for France, for the modest salary of three thousand francs, or six hundred dollars. In 1854 he assumed, in addition to his work here, the duties of a lectureship, which fourteen years later became a full professorship, in the Sorbonne.

M. Deville's first researches were in organic chemistry, and began to attract attention in 1840, when he published a remarkable study of turpentine-oil and various derivatives of the terpenes, the carefully tabulated results of which form the chief basis of our knowledge of the different isomeric states of this group. It was followed in 1842 by a research on toluene, which has had an important bearing in the researches on the aniline colors.

He soon afterward turned away from this branch of the science to devote himself to mineral chemistry, in which, says M. Pasteur, he for thirty years held the scepter in France and Europe.

His first great discovery in this department was announced in 1849, when he demonstrated the existence of anhydrous nitric acid, and de-

scribed its preparation by the action of chlorine on silver nitrate, and its properties. The possibility of the existence of monobasic acid anhydrides had previously been disputed. In 1852 he published in the "Annales de Chimie et de Physique" an important paper upon the metallic carbonates and their combinations, and in 1853 he discovered a new method of mineral analysis. In 1855 he began the famous research on metallic aluminium, which proved, says his biographer in "Nature," to be one of the crowning features of his life-work. He was furnished the means by which he was enabled to carry his experiments to success by Napoleon III, who was looking forward to the application of the qualities of a metal of so light a specific gravity to the making of armor and helmets for the French cuirassiers. The anticipation proved to be a mere dream, and impracticable; but the ambition in which it was bred was caused for once to minister to the lasting benefit of mankind. With the means thus furnished, M. Deville was able to carry on his experiments on a large scale, and so rapidly that even in the same year in which he began he displayed at the exhibition in Paris massive bars of the metal, that had hardly been seen before in a pure state. The study of this metal and of its metallurgical production, as well as of the various compounds of aluminium, carried out during a series of years, forms, says "T. H. N." in "Nature," one of the most remarkable and complete contributions made to inorganic chemistry within a recent period. The metal is now prepared in one English and two French establishments according to Deville's perfected process, which consists essentially in heating the double salt (chloride) of aluminium and sodium with metallic sodium, fluor-spar or cryolite being added as a flux, and is used for a variety of objects where lightness, strength, and freedom from oxidation are demanded, and in many valuable alloys, of which it forms the essential part. It has not come into as extensive use as Deville hoped it might, for it is still too high in price and is hard to weld. The operations with aluminium have resulted in building up other industries, such as the production of bauxite and cryolite, and the manufacture of metallic sodium, the price of which sank in ten years from two thousand francs to fifteen francs per kilogramme. In 1863 M. Deville, in connection with Caron, applied his aluminium method to the manufacture of magnesium, and made it possible to produce that metal in commercial quantities. With Debray he carried on exhaustive researches from 1859 to 1862 on the metals of the platinum group, in which he applied the oxyhydrogen blow-pipe on a large scale to the fusion of platinum, now for the first time accomplished. This led him to operations at higher temperatures than had ever before been attained, except perhaps casually, involving the artificial production of crystalline minerals, which has since been carried out by other chemists to a larger extent, and numerous determinations of the vapor densities of bodies that are ordinarily solid, like the chlorides of aluminium, iron, and va-

rious rare metals, by means of which the molecular weights of various compounds have been satisfactorily ascertained.

M. Deville's highest title to honor, says M. Würtz, rests upon his having introduced to science the idea of dissociation as a particular method of decomposition, the understanding of which has rendered the grandest services to theoretical chemistry. Decomposition was believed, previous to his researches in this line, to be a simple phenomenon, taking place and being repeated with each body at a fixed temperature. M. Deville has shown that it is not always so, but that decomposition is accomplished in certain cases by degrees, within certain limits of temperature, in such a manner that it is arrested at a given temperature, by the establishment of an equilibrium between the decomposing body and the products of its decomposition. The principle explains a variety of occurrences among thermal phenomena that have hitherto not been accurately accounted for, and may be defined, says "Nature," "as the property of many compound bodies to undergo partial decomposition under the influence of heat in confined spaces, until the liberated gas or vapor has attained a certain tension, greater or less, according to the temperature. So long as this temperature remains constant, no further decomposition takes place, neither does any portion of the separated elements recombine. If the temperature be raised, decomposition recommences, and continues until a higher tension of the liberated gas or vapor, definite for that particular temperature, is attained. If the temperature falls, recomposition ensues, until the tension of the residual gas is reduced to that which corresponds with the lower temperature. The enunciation of this simple but far-reaching principle has thrown light upon a number of phenomena, such as the formation of minerals, the apparent volatilization of solids, etc.; and has been the fruitful source of countless novel discoveries."

Other researches with which M. Deville's name is associated are those on boron, which he prosecuted in company with Wöhler in 1857, on the preparation of silicium and its compounds with copper (1863), a new calorimeter, on the changes attendant upon the mixture of liquids (1870), and the examination of a large variety of minerals and natural products. A few years ago he was appointed on the commission to prepare the international normal standard of the measure of a metre, and acquitted himself of the task allotted to him with characteristic devotion to the interests of science.

His simplicity was the predominant quality in M. Deville's character, and distinguished him alike in his social relations and in his scientific labors. He kept away from the theoretical disputes in which many of his colleagues were too prone to indulge, finding abundant employment for his own resources "in attacking the still unsolved problems of inorganic chemistry"; and he is said to have gone so far as to declare the whole theoretical tendency of modern chemistry, the

atomic theory not excepted, to be a superfluous speculation. His methods, his apparatus, and the few fundamental principles he has enunciated, were all alike simple. He was much beloved by his students, and was devoted to them. Though the labor of drilling the pupils of the Normal School year after year in the same elementary principles must have been irksome in the extreme, he was always kind and just, always ready with counsel and help. His proverbial tenderness toward candidates in the public examinations is illustrated by an anecdote:

"Let us see, monsieur," he asks; "of what is water composed? . . . Of o—?"

"Xygen," the pupil replied.

"And what else? . . . Of hy—?"

"Drogen," added the candidate.

"That is right, monsieur. Thank you."

M. Pasteur describes him as small in stature, with a high forehead, lively eyes, and an impulsive walk; a man who might have compared the beating of the blood in his veins to that of the waves in the river Rhône.

M. Deville's chief works include his contributions to the "Annales de Chimie et de Physique" concerning the properties of aluminium and his experiments with it; a comprehensive work on the same subject ("De l'Aluminium, ses Propriétés, sa Fabrication"), published in 1859; a report on the fusion of steel in the reverberating furnace without using a crucible (1862); and his large work on the metallurgy of platinum and the metals that accompany it (1863). Among his more important contributions to the Academy of Sciences are papers on the three molecular states of silicium and a memorandum on the production of high temperatures.

M. Pasteur relates that at one time, when he thought that he himself was about to die, M. Deville rallied him by telling him that he must live to pronounce his funeral address. The duty was beautifully fulfilled by M. Deville's fellow-worker in the fields of investigation. On the 5th of July last, M. Pasteur pronounced an affectionate funeral eulogy on his deceased colleague, beginning with the appropriate apostrophe: "Thy sympathetic features, thy gayety of spirits, thy frank smile, the sound of thy voice, still go with us and live among us. The ground that bears us, the air we breathe, the elements which thou didst love to question, and which were always so docile in answering thee, could tell us of thee if there were need of it. The entire world knows the services thou hast rendered to science, and, beyond the mountains and the seas, every man who is interested in the progress of human thought wears mourning for thee."

## ENTERTAINING VARIETIES.

—— *Four-footed Outlaws.*—"France must elevate her soul to the height of the situation," wrote Louis Napoleon after the battle of Gravelotte. She didn't; but the *instincts*, as we are pleased to call the talents of our dumb fellow-creatures, seem really able to adapt themselves to any possible emergency. In the border-lands of culture, in the Jura, the Cheviot Hills and the Adirondacks, there are deer and foxes that can not be outwitted by ordinary means, and succumb only to an in-pre-calculable combination of circumstances. Among the half-wild cattle of the Texas frontier there are individuals whom the Genius of Civilization has given up for lost, human ingenuity being no match for such instincts as theirs. Even in the Belgian Ardennes, where every acre of woodland is under the control of professional foresters, a runaway pony managed to elude his pursuers for more than eight years. His haunts were pretty well known, experience and emulation had sharpened the wits of his persecutors, but all plans to recapture him went somehow aglee—he was not only cautious but caution incarnate the quintessence of his five senses seemed concentrated on the problem of preserving his liberty. A single glance enabled him to distinguish harmless bipeds from dangerous or suspicious ones; old crones in quest of their milch-cows, and berry-gathering boys, he simply ignored; but at the approach of a game-keeper he instantly vanished from human sight or at least out of rifle-range. He used to make his headquarters in the dense pine-jungles of the Sambre highlands, but in night-time he sometimes revisited the glimpses of the moon on business that finally brought him to grief. After he had repeatedly stampeded the mares of a highland stud-farm, the proprietors put a price on his head, and—*ne Theseus quidem contra plures*—the wary outlaw was at last shot near the Col de Grappe, on the border of Lorraine.

—— *A Paragon of Ugliness.*—The ancient Huns seem to have been the ugliest of all the ugly races of Central Asia; and the homeliest individual—with one exception—was probably the "veiled Prophet of Bokhara," Mullah Ibn Said, the repulsiveness of whose features was so overpowering that he did not dare to show himself without a mask, for which he afterward substituted a golden veil, whence his surname, Almukana—"The Veiled One." Yet his biographer, Ibn Chaldir, assures us that an elder cousin of Almukana, who proudly disdained to hide his face, exceeded him not only in erudition but also in ugliness. This man, called Kofta Ben Lukas, and famous as a philosopher and grammarian, must actually have been the *ne plus ultra* of homeliness. He was an accomplished teacher of languages, but the only pupils he could procure at the Lyceum of Bagdad were adult males, of exceptional fortitude, all others being overcome by the terrors of his presence. When Almohadi, the Caliph, inquired after the best teacher of the Persian language, the name of Ben Lukas was mentioned among those of the highest merit, but when further inquiries proved this worthy to be identical with the formidable licentiate of Bagdad, Almohadi, who wanted the instructor for his own son, was earnestly advised to alter his choice, as a prince of such tender years would surely succumb to nervous prostration at the first grammatical interview. The Caliph ridiculed these fears, and ordered the grammarian to report at his court; but no sooner had

Kofta Ben Lukas made his salaam to the Commander of the Faithful, than he was presented with a purse of four hundred and fifty golden denari, and offered fifty more if he would leave the capital before night. He had been summoned through a misunderstanding, they told him, and the Caliph did not wish it to become public that by his mistake an illustrious scholar had thus been foolishly interrupted in his studies.

—— *Marshal Vendôme.*—If cynicism had not ceased to rank as a branch of philosophy, France could boast of having produced the greatest philosopher of the last twenty centuries. Louis-Joseph, Duke of Vendôme, great-grandson of Henry IV, was a man of principles. He used to take a bath on the first day of every month, and during the remaining four weeks avoided water in every form—his toilet-articles being limited to a jackknife and a piece of beeswax. On the day of the monthly purification his rooms were also cleansed, his study with a broom and his bedroom with a shovel, for a pack of hunting-dogs shared his couch and often reared their progeny under his bed. The destruction of all earthly laundries would not have shaken the peace of his manly soul; his underwear consisted of a buckskin shirt and short socks of the same material, his bed of a bunk and three blankets, one of them rolled up in the shape of a pillow. At the table of the Comte d'Amblève he often gorged himself till he could hardly rise from his chair; but at home he used to avoid that difficulty by taking his meals in bed, and there were weeks when he did not leave his bed at all. Brushes, combs, looking-glasses, marriage-rings, prayer-books, handkerchiefs, soap and wash-basins, were luxuries the noble warrior managed to dispense with; ceremonies were his grand aversion, and the demerits of the frail sex the subject of his daily anathemas. But this man, whom the priests accused of all the vices mentioned in Peter Lombard's revised catalogue, was a Mars on the battle-field, the idol of the army, and, in the opinion of Prince Eugene, the one soldier who could have saved France if the petticoat-government had not thwarted him.

—— *Curious Predictions.*—Mother Shipton, too, has foundered on a cliff that is strewed with the wreck of numerous vaticinations. On this side of the Indus, it seems, Messiahs are not sufficiently encouraged to venture upon a second advent. "This whole business of the Delphic fraternity," says Professor Hegel, "is nothing but *Scheiben-schiessen im Nebel*—target-practice in a fog." Still, it must be admitted that some of the marksmen have scored remarkable hits. Not all prophets have "prophesied after the event," for it can not be denied that, eight years before the birth of Napoleon Bonaparte, the author of the "Contrât Social" (Jean Jacques Rousseau) recorded in print the following *augurium:* "J'ai un présentiment que la Corse produira un homme qui étonnera le monde"—("I have a presentiment that Corsica is going to produce a man who will astonish the world)." Napoleon himself believed in omens and portents as firmly as any Roman Cæsar, and openly professed his confidence in certain lucky days (the 2d of December and 24th of October, for instance). He confessed to Las Casas that in the night before the battle of Leipsic he was on the point of revoking all his orders and abandoning his position, having been seized with a sudden misgiving, which only the stronger fear of ridicule helped him to overcome; and after his Russian campaign he certainly had some excuse for being a little superstitious. In the winter of 1807 the arbiter of Europe took it into his head one day to consult the famous *clairvoyante* Lenormand, whose feats in "astrology" were setting all Paris agog. The Pythoness told him that his fears of another outbreak in Austria were unfounded. "Your power has not culminated yet,"

she said, "your star will keep in the ascendant for another five years; but after that it will decline and be eclipsed for ever." The downfall of the Roman Empire was foretold by many portents and prodigies, of which even the elder Pliny enumerates a long list; and the testimony of numerous Spanish historians makes it certain that long before the birth of Columbus the ancestors of Montezuma were frightened by an ominous prophecy which presaged the overthrow and total ruin of their nation. Strange men, cunning, strong, and altogether invincible, were to come from the *East* and consume the race of the Aztecs as the hoar-frost of the Cordilleras is consumed by the morning sun. Lord Bacon's *bonmot* respecting forebodings might be applied to this kind of prophecies, that "a man troubled with misgivings has commonly good reasons to expect things to go amiss"; but, even in the noontide of prosperity, such omens of a sudden night have now and then appeared. King Rodrigo, a year before the altogether unexpected invasion of the Saracens, had a vision that "prostrated his mind like a sentence of death," and on the battle-field of Xeres, when squadron after squadron of his iron-clad warriors was borne down by the onset of the Moslem fanatics, he turned to the Bishop of Toledo with the words: "*Está venido!*—it has come! These horses and these riders I saw approaching in my trance a twelvemonth ago; they are going to overtake me now."

—— The principal literary event in the interest of popular science in Mexico is the issue of a "Pocket-Cyclopædia of Useful Knowledge" ("Enciclopedia Manual de Ciencias útiles," three vols., Puebla, Manzanares & Co., 1881)—a publication which seems to enjoy an increasing popularity, though the editor has been unable to deprecate the hostility of the orthodox press. "The eminent publishers have discontinued the sale of transparent French cards," says the "Correo Nacional," "but we should like to know how and where they would draw the line which makes immoralities detestable in colored lithographs, which are endured in the form of black types on the pages of the 'Enciclopedia.' Don Yriarte, the editor of that publication, affects to doubt the fact that King Philip II possessed a duplicate skeleton of St. Laurentius, and plainly insinuates that '*at least*' one of those relics must have been spurious. History proves that the skeletons in question were originally owned by ecclesiastical establishments of the highest respectability, and we need hardly remind our readers that the Bishop of Velez Malaga recognized the miracle of the dualism as a special dispensation of Divine Grace. Don Yriarte's views are therefore utterly untenable, and valuable only as an additional proof of the immoral tendency of his writings." "In his article on 'Church Government' and the 'Sequestration of Ecclesiastical Domains,'" says the "Espectador," "the editor of the 'Enciclopedia' quotes the speeches of Emilio Castelar and others of his class, while such writers as the Duke of Braganza y Nunez (author of the 'Sacred Petticoat of Santa Eulalia') have never been permitted to offer their views. Nay, in a review of the 'History of International Statistics,' Don Yriarte has no hesitation in illustrating the applications of the 'Rule of Three' by certain formulas whose promulgation would be so directly subversive of the chief dogma of the Trinitarian Church that we must decline to sully these pages" (*contaminar estas páginas*) "by quoting them. We, with thousands, pray that the re-establishment of the Holy Inquisition may put a stop to such outrages on the interests of the national Church—unless the 'Enciclopedia' will revoke its atheistical teachings, and become such an organ of science as the great body of intelligent Mexicans will admit with confidence into their homes."

F. O.

—— The letters of Sir Charles Lyell have just appeared, in two solid volumes, and contain much that is interesting. The following extracts are from those written about 1830, when he was bringing out the first edition of his "Principles of Geology," and advocating what was at that time the heresy of uniformity against catastrophe in the earth's great geological changes:

—— "I shall be glad to hear your honest opinion of the work, regarded as one comprehensible to the uninitiated. I am afraid that what delights my friend Scrope more than all—the honest history of the Mosaico-geological system—will hurt the sale. D'Aubisson said this morning: 'We *Catholic* geologists flatter ourselves that we have kept clear of the mixing of things sacred and profane, but the three great Protestants, Deluc, Cuvier, and Buckland, have not done so; have they done good to science or to religion? No; but some say that they have to themselves by it. Pray, gentlemen, is it true that Oxford is a most orthodox university?' 'Certainly.' 'Well, then, I make allowances for a professor there, dividing events into ante- and post-diluvian: perhaps he could get no audience by other means.'"

—— "I have just had this morning a famous geologico-botanical discussion with Professor de Candolle, and am almost certain that my spick-and-span new theory on this subject will hold water."

—— "Considering that no lectures on geology are authorized in the Sapienza (Rome), I was amused at the late French embassador, Count de Rayneval, having made a splendid collection of tertiary fossils in the hill of the Vatican, which he and Ponza are preparing for publication. They are curious, and intermediate it seems between Miocene and Pliocene. For five years they have worked away under the Pope's window, to throw light on the earth's antiquity."

—— "Longman has paid down five hundred guineas to Mr. Ure, of Dublin, for a popular work on geology just coming out. It is to prove the Hebrew cosmogony, and that we ought all to be burned in Smithfield. So much the better. I have got a rod for the fanatics from a quarter where they expect it not. The last Pope did positively dare to convoke a congregation, and *reverse* all that his predecessors had done against Galileo, and there was only a minority of one against; and he instituted lectures on the Mosaic cosmogony to set free astronomy and geology. How these things are so little known in Paris and London Heaven knows. They are golden facts, and I find the state of the question here to shame the Granville-Penn school of England."

—— "Some thirty years ago I was told at Bonn of two processions of peasants who had climbed to the top of the Petersberg, one composed of vine-dressers, who were intending to return thanks for sunshine and pray for its continuance; the other, from a corn district, wanting the drought to cease and rain to fall. Each were eager to get possession of the shrine of St. Peter's chapel before the other, to secure the saint's good offices, so they came to blows with fists and sticks, much to the amusement of the Protestant heretics at Bonn, who I hope did not by such prayers as you allude to commit the same solecism occasionally, only less coarsely carried out into action."

—— "*Cuvier* is in great force, and gave a famous *soirée* the other day. He has been chosen by the ministers to defend their municipal law in the tribune: two months of his time will thus be lost to science. He talked to me of the Catholic question, our corporation rights, etc., and not a word could I get on

natural history. Yet this year he has come out with four volumes on fish, and eight more will appear in two years. He has received between £2,000 and £2,200 for it, whereas no other person in Paris could persuade a librarian to publish one volume for nothing. He is also publishing another edition of his 'Règne Animal,' and other things. He has been very obliging to me, for, on my applying for casts of animals for Mantell, who has been begging in vain for a long time, he gave me an order for whatever I liked; so I have sent off from the museum a huge box with casts of *every* thing."

—— "I got into *Cuvier's sanctum sanctorum* yesterday, and it is truly characteristic of the man. In every part it displays that extraordinary power of methodizing which is the grand secret of the prodigious feats which he performs annually without appearing to give himself the least trouble. But, before I introduce you to his study, I should tell you that there is first the museum of natural history opposite his house, and admirably arranged by himself; then the anatomy museum, connected with his dwelling. In the latter is a library disposed in a suite of rooms, each containing works on one subject. There is one where there are all the works on ornithology, in another room all on ichthyology, in another osteology, in another *law* books (!) etc., etc. When he is engaged in such works as require continual reference to a variety of authors, he has a stove shifted into one of these rooms, in which everything on that subject is systematically arranged, so that in the same work he often takes the round of many apartments. But the ordinary studio contains no book-shelves. It is a longish room, comfortably furnished, lighted from above, and furnished with eleven desks to stand to, and two low tables, like a public office for so many clerks. But all is for the one man, who multiplies himself as author, and, admitting no one into this room, moves as he finds necessary, or as fancy inclines him, from one occupation to another. Each desk is furnished with a complete establishment of inkstands, pens, pins to pin manuscripts of the same work, etc. There is a separate bell to several desks. The low tables are to sit to when he is tired. The *collaborateurs* are not numerous, but always chosen well. They save him every mechanical labor, find references, etc., are rarely admitted to the study, receive orders, and speak not."

—— "*Brongniart*, who in imitation of Cuvier has many clerks and *collaborateurs*, is known to lose more time in organizing this auxiliary force than he gains by their work, but this is never the case with Cuvier. When I went to get Mantell's casts, I found that the man who made molds, and the *painter* of them, had distinct apartments, so that there was no confusion, and the dispatch with which all was executed was admirable. It cost Cuvier a word only."

# CORRESPONDENCE.

## THE DURATION OF HUMAN LIFE.

*Messrs. Editors.*

I HAVE read with great interest an article having the above title, by M. De Solaville, in the November issue of "the Popular Science Monthly." As the article is so conclusive as to the average age of man, with one singular exception in relation to the patriarchs, living before the flood, it has taxed the ingenuity of many able as well as serious minds to account for the wonderful discrepancy in this case. Buffon has given, as the writer quotes him, the reason of this difference to be, that "before the flood, the earth was less solid, less compact than it is now. The law of gravitation had acted for only a little time, the productions of the globe had less consistency, and the body of man, being more supple, was more susceptible of extension. Being able to grow for a longer time, it should, in consequence, live for a longer time than now." Hensler, he tells us, has given a different reason, referring the apparent conflict to the different modes of dividing time. Voltaire rejected, on the authority of the writer, "the longevity assigned to the patriarchs of the Bible," but accepts without question the longevity ascribed to certain men in India, who reached the age of one hundred and twenty years.

On a full examination of the question of patriarchal longevity, the disparity of their ages to those of later times disappears. A very slight error in the translation of the Hebrew numbers has led to all the apparent disparity. The age of the antediluvians was not to exceed one hundred and twenty years. Genesis vi, 3: "And the Lord said, my spirit shall not always strive with man, for that he also is flesh, yet his days shall be an hundred and twenty years." This was the regular good old age of men with special variations, both before and for some time after the days of Abraham.

In reading *concrete numbers* the Hebrews gave the larger number first, thus: Ninety *and* seven for ninety-seven, forty *and* seven for forty-seven. The reversal of this rule in the translation of Genesis v, 3–5, as an illustration, will show the error in all similar cases. "Adam lived a hundred and thirty years and begat a son," etc. This is correct, according to the rule; Seth was born when Adam was one hundred and thirty years old, and was his last child. But if the rule were here reversed, as it is in the authorized version in the fifth verse, it would read thus: Adam lived thirty hundred years, and begat a son! This shocked the consciousness of the Christian translator, and he was driven to the true rule of the Hebrew uses in case of *concrete numerals.*

In the fifth verse we have the force of the violated rule, thus: "And all the days that Adam lived were *nine hundred and thirty years, and he died*"! A. V. The true reading by the rule would be, "And all the days of Adam, which he lived, were a hundred years, and thirty and nine years, and he died," making the entire age of Adam one hundred and thirty-nine years, instead of nine hundred and thirty years.

It will be seen, on examination, that concrete numeral adjectives, in Hebrew as in other languages, agree in number with their nouns. In the case cited in the A. V. the *nine* is made to agree with *hundred* in the singular and not with *years* in the plural. The error is seen at a glance, for the difference between "*nine* years" and "*nine hundred* years" is too great to be overlooked in any careful translation of a sacred book. The translator assumed that *nine* here agreed with *hundred*, when it had no such agreement; hundred in the text is itself a concrete numeral, and separately agrees with years, meaning a hundred of years. At the date of this writing the Hebrews had no means of writing "nine hundred," or any number of hundreds above one, without repetition or circumlocution. There were then none of the masoretic points in use. In the case of the age of Terah, the father of Abraham, the translators have made the attempt to make two hundred out of one hundred in the word *mathim* [מאתים], used in the plural as it might be to agree with years, thus making Terah two hundred and five instead of one hundred and five years old, at his death; holding the theory that the word *mae* (or one hundred) would, in the plural, *mathim*, make two hundred. This is contrary to all rule. The Hebrews could, by pluralizing a numeral, less than ten, add tenfold to the unit, thus: hemosh, *five;* hemoshim, *fifty.* This rule, applied in the case of Terah, would make him ten times one hundred and five years old, or one thousand and fifty years old. In the case of Terah the historic record conclusively contradicts the translation, and hence demonstrates the rule that pluralizing one hundred does not, in the Hebrew tongue, make two hundred,

while as to all numerals between *two* and *ten* the rule might apply thus: Sheleshi, *three;* sheleshim, *thirty;* and in like manner to ten. With these corrections, referring to the ages of the patriarchs before the Noachian deluge, the article of M. De Solaville would show a wonderful uniformity in the age of man since the dawn of history.

From Adam to the flood the ages would read as in the table below, subject to a few uncertainties in the numbers *below one hundred*, as the numerals are sometimes pluralized for purposes of agreement, when they were not increased tenfold. These cases are not always certain; the table to the flood is substantially true.

The table is added, giving the ages of each at the time of his death:

| | | | | | |
|---|---|---|---|---|---|
| 1. Adam, | 130 | years | and not | 930 | years. |
| 2. Seth, | 121 | " | " | 912 | " |
| 3. Enos, | 114 | " | " | 905 | " |
| 4. Cainan, | 119 | " | " | 910 | " |
| 5. Mahalaleel, | 122 | " | " | 895 | " |
| 6. Jared, | 117 | " | " | 962 | " |
| 7. Enoch, | 114 | " | " | 365 | " |
| 8. Methuselah, | 124 | " | " | 969 | " |
| 9. Lamech, | 117 | " | " | 777 | " |
| 10. Noah, | 159 | " | " | 950 | " |
| Averages, | 120 + | years | " | 858 | years. |

Should the editors of "The Popular Science Monthly" publish this note, it might be the means of calling the attention of the revisers of the Old Testament to the examination of cases of apparent errors in the reading of Hebrew numbers. The late Dean Stanley, for years before his death, insisted that the numbers in the Old Testament were, in many instances, entirely too high. The correction of these apparent errors, the Dean believed, would relieve the Bible of many objections now urged against this important record of ancient times.

Most truly yours,

CHARLES S. BRYANT.

ST. PAUL, MINNESOTA, *October* 28, 1881.

## THE COPYRIGHT OF IRVING'S WORKS.

*Messrs. Editors.*

THE last issue of the "Monthly" contains, in an article by Mr. B. V. Abbott on the "Progress of Copyright Law," a paragraph in regard to the copyright on Irving's works, which seems to us calculated to convey an erroneous impression.

Mr. Abbott, intending to paraphrase the decision of the judge in our suit to restrain the publication, under the title of "Irving's Works," of a volume containing only a portion of Irving's earlier and unrevised writings, says, "Now that any one may publish Irving's works," etc.

It is not the case that any one may at present publish Irving's works. His latest writings, including the crowning work of his life, "The Life of Washington," and including the only revised and authorized issues of his earlier volumes, are still protected by copyright.

The words of the judge had reference simply to the material comprised in the volume whose publication we sought to restrain. This contained only the earlier and unrevised writings (in some cases reprinted from their original issue as "magazine" articles), which were no longer protected by copyright.

Our application was based on the ground that it was an attempt to deceive the public to offer for sale as Irving's works something that was very different from the revised and complete works as known and published for many years, and that, so far as such volume, under such misleading title, was sold, it was an injury to the property of Irving's nieces, who are the owners of his copyright.

For the support of this claim, however, the court decided that the legal grounds were insufficient. Requesting the favor of the publication of this explanation, we are

Yours respectfully,

G. P. PUTNAM'S SONS.

NEW YORK, *January* 9, 1882.

# EDITOR'S TABLE.

### *THE PRACTICAL STUDY OF MIND.*

THE progress of knowledge and inquiry is every day bringing into clearer practical contrast the two methods of studying mind: that which regards it as an abstraction, known only in consciousness, or the metaphysical method; and that which regards it as the endowment of an organic structure by which mental phenomena are determined, or the physiological method. The former refuses to recognize the corporeal substratum of mental effects as essential to its inquiries; the latter holds it to be the foundation of mental science. Both resort to introspection, or the study of psychical processes in consciousness, as a legitimate source of knowledge; but, while the metaphysician will go no further, the scientific

psychologist holds that the material conditions of mind are of supreme importance to the understanding of its laws. To the metaphysician the brain is a thing of but little interest, which he contentedly leaves to the phrenologist, or he avoids it as opening the dangerous way to materialism; the mental physiologist is attracted to brain-studies because they open the way to the largest truth, because they elucidate the conditions of mental action, connect mind with character, explain individuality, and disclose the laws of improvement on the hitherto neglected side of human nature. Let us here note some of the differences in the practical bearings of these two methods.

If we take the phenomena of mental growth—certainly of great importance—we find that the metaphysician can give us but little help in treating it. Growth is primarily a biological conception, yet mind grows. But mental physiology, or objective psychology, taking into consideration the vital conditions, can deal rationally with psychical development. The subject of mental growth is at the root of education. To the metaphysical teacher, ventilation, exercise, clothing, and diet, as they are material concernments, are of but indifferent moment; while to the well-instructed psychological teacher they are the fundamental conditions of successful work. He knows that he can only cultivate the mind in accordance with the laws of the organism of which it is a part. To the metaphysician, mind is an independent entity in an upper sphere of being; to the mental physiologist, it is the activity of an organized mass of nerve-cells and filaments, charged with blood and carrying on processes of thinking and feeling under the laws of nutrition. If the organization is low, or perverted by hereditary taint, or if the blood is thin or impure, so that the nutritive processes are sluggish or enfeebled, he understands that the bodily growth will be hindered, and mental action correspondingly lowered in vigor.

Another illustration of the contrast of the two methods is furnished by the phenomena of insanity. To the metaphysician in all the metaphysical ages insanity was a sealed book, and by that method would have so continued to the end of time. And this, for the reason that the metaphysician can not or will not recognize in any adequate degree the dependence of psychical effects upon physiological conditions. He refuses to see that it is the brain which, in its health, carries on all the normal operations of mind. He will not have the mental and the corporeal united. He will not degrade the dignity of his subject by mixing it with base material considerations. Hence, of diseased mind and the causes and laws of its morbidity, he knew nothing, and could know nothing. It is to the physician, and not the metaphysician, to the anatomist who studied the structure of the brain, and to the physiologist who studied its functions, and the pathologist who studied its diseases, that we owe all our knowledge of that most practical of all subjects, irregular and abnormal mental action.

And now we have another interesting illustration of the contrast of these two methods of study exemplified in the able work on suicide of Dr. Morselli, noticed in our December number. It is there shown by multitudinous proofs, and it was illustrated in our notice, that the phenomena of suicide observe a regularity to which we give the name of law. But more than this, it is proved that suicidal regularity has an orderly variation—corresponding to variations of external condition—climate, season, country, age, sex, race, cultivation, and social circumstances. The question is, What is the nature of the relation? Nobody will pretend that it is accidental. Is it not, then, dynamic and causal?

Now, the metaphysician can do nothing with the problem, because his

method of studying mind excludes the corporeal order. To him mind is an abstraction, mysteriously related to matter, but not coerced by it. Mind, he maintains, is free; matter is enslaved by law. Men accordingly kill themselves because they choose to—because they are free agents and depraved beings. On this view the facts can not be explained, and no science of the subject is possible. But, on the other hand, if we take all the elements of the subject into account, if we regard man in the light of common-sense as a unified being, and all mental effects, whether healthful or morbid, as determined by organic conditions, we are then able to understand why the laws of suicide answer to the laws of external phenomena. We can then see how suicide, though a mental phenomenon, may be due to physical causation. When we consider man as a sensitive organism, so delicately constituted as to be acted upon in a thousand ways by the complex and ever-varying forces of nature, it creates no surprise to find that the averages of self-destruction can be predicted from year to year, and even from month to month, in any country and at any season. If we put the concrete brain in the place of the abstract mind, the subject, though closed to metaphysics, is opened to science. For the brain, the most susceptible part of the organism, is liable to be disturbed and morbidly affected both by physical conditions and passional strains. No man now denies that insanity is a corporeal fact—a derangement of the action of the material organ of feeling and thought. We know that suicide is a marked accompaniment of the cerebral disorder of insanity. So marked, indeed, is it that, even where there is no other evidence, it is often held by coroners' juries that the act of suicide presumes mental derangement. But the morbidities of the brain have an infinite series of gradations. Their obscure initiations take the form of cerebral weakness, debility, exhaustion, accompanied it may be by discouragement, depression, and weariness of life, which may impel to suicide, or go on to confirmed melancholia. When we can sufficiently escape from metaphysical prejudice to regard mind as practically but brain activity, dependent upon healthy nutrition and all that that implies, it will mark an epoch in the progress of the science of human nature.

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### *A NEW FEATURE.*

We last month began a department under the title of "Entertaining Varieties," intended to be a modified form of the *feuilletons* which have served to increase the popularity and consequently the usefulness of many European periodicals. It will consist of readable miscellaneous fragments of all sorts, but it is not intended to limit it to mere fugitive things, as it may afford a place for continuous papers of a light and entertaining kind.

We are already able to promise something of this sort; and intend very soon to commence the publication of a series of sketches of peculiar interest, entitled

THE MOUNTAINS OF THE MOON;

OR,

TRAVELS AND ADVENTURES OF HAKIM BEN SHEYTAN.

TRANSLATED BY F. L. O., WITH NOTES BY THE TRANSLATOR.

Many strange things have latterly come forth from the recesses of Africa, but nothing more remarkable than these curious revelations. The new chronicle may be very apocryphal, but it is sure to be amusing, and will probably prove also instructive. Hakim Ben Sheytan, we are informed, was a Mussulman doctor of Tripoli, who accompanied a military expedition to the interior of Africa, and by some mischance, straying from his party, found himself in a coun-

try inhabited by a curious race, called the *Monakas*, or the *Monga Fants*, a people distinguished by their wonderful proficiency in mechanical arts, but still more by their preposterous domestic habits, their singular ideas, and their strange superstitions. The curiosities of *Monakistan* rival the wonders of Houyhnhnm Land, and the narrative of the explorer abounds with incidents and graphic descriptions as well as with scientific intimations that throw a suggestive light upon the origin of the follies and vices of civilized life. The translator is widely known as an original, vivid, and fertile writer, who has the secret of making science attractive, and we venture the prediction that his work will mark a new stage in the history of entertaining literature.

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## LITERARY NOTICES.

THE CONCEPTS AND THEORIES OF MODERN PHYSICS. By J. B. STALLO. International Scientific Series. D Appleton & Co. Pp. 313. Price, $1.75.

WE last month called attention to this work as one of the ablest in the series to which it has been contributed. It is not devoted to the extension of any branch of science, but is an inquiry into the validity of some of the conceptions which are commonly accepted as at the foundation of all science. It is therefore, as might be expected, a profound book. Dealing not with the operations or results of the special sciences, but with the laws of thought by which science is created, and showing how radical scientific conceptions require to be still further corrected and clarified, and presenting the case with a closeness of reasoning that can not be further compacted, the volume would be discouragingly difficult but for the perfect art of its exposition and the crystal clearness of its style. It is much easier to characterize this book than to analyze or review it. In a brief notice, we can convey only a general idea of its purpose, and this may perhaps be best done by referring to some of the circumstances in which it originated.

It may be proper to say that the author is a German by birth, and came to this country at about the age of seventeen. He was early familiar with science, and after his arrival in the United States, as we are informed, he lectured on chemistry for some years in an Eastern college. But he at length concluded to adopt the profession of law, and chose Cincinnati as his residence. Pursuing his profession successfully, Judge Stallo became widely known as a gentleman of scholarly accomplishments, of independent opinions, and liberal politics.

But he is also remembered by many as an author, having a number of years ago written a metaphysical treatise of such marked ability for one of his youthful years, that the most brilliant expectations were formed of his intellectual future. But as time passed, and nothing further was heard from him in the way of book-making, it was thought that he had abandoned his scholarly studies and, German though he was, had succumbed to the American passion for money-making. So much, at least, we have heard said by the disappointed admirers of his early work.

Yet Judge Stallo had neither lost his interest in philosophical studies nor relinquished their pursuit. Though business, public duties, and the care and culture of a growing family, had imperative claims, all his leisure hours were given with great assiduity to the work of systematic original inquiry—an inquiry, moreover, that was strictly in the line of his early intellectual efforts.

Our author has therefore not been idle. Yet there were obviously strong reasons connected with the nature of his investigations which compelled delay in the publication of his views. The task which he assigned to himself was not only one that involved comprehensive research and prolonged reflection, but it was the result of a profound revolution in his own mental history. Judge Stallo's two books, though separated in their dates by a generation of time, are far more widely separated in their ideas and purposes. They represent opposite schools of doctrine, opposite poles of thought, and different stages of mental growth in the race. The first was thoroughly metaphysical and the last is even more rigorously scientific. Judge Stallo has

passed from one method of thought to another by slow processes of intellectual growth which required time as well as exertion, and he has pushed further on in the scientific direction and away from the metaphysical position than perhaps any other writer. How complete has been the revolution in his own mind is well illustrated by a passage in his preface referring to his former work.

He says: "I deem it important to have it understood at the outset, that this treatise is in no sense a further exposition of the doctrines of a book ('The Philosophy of Nature'—Boston: Crosby & Nichols, 1848) which I published more than a third of a century ago. That book was written while I was under the spell of Hegel's ontological reveries—at a time when I was barely of age, and still seriously affected with the metaphysical malady which seems to be one of the unavoidable disorders of intellectual infancy. The labor expended in writing it was not, perhaps, wholly wasted, and there are things in it of which I am not ashamed, even at this day. But I sincerely regret its publication, which is in some degree atoned for, I hope, by the contents of the present volume."

Having slowly recovered from his serious Hegelian attack and mastered in a very thorough manner the principles and methods of modern physical science, it was inevitable that Judge Stallo's attention should be forcibly drawn to the relations of these two systems, and to the question how far science is still dominated by the old metaphysical method. It is his opinion that the metaphysical influence lingers and rules in scientific thought to a greater degree than is commonly suspected. It is generally supposed that physical science, at any rate, has quite freed itself from the mischievous tendencies of metaphysical speculation, and that Newton's admonition to the physicists, "to beware of metaphysics," has been so effectually heeded that this branch of investigation may be taken as illustrating the true scientific method in its purity and perfection. The author of the "Concepts and Theories of Modern Physics" holds that this assumption is but partially true, and the present work is devoted to a comprehensive examination of what may be regarded as basal theories of physics, to the evidence that may be given of their errors, and to tracing out the metaphysical origin of these errors. We can not here do better than to restate his position as given by himself in the preface to his book: "It will be seen at once, upon a most cursory glance at any one of the chapters of this little book, that it is in no wise intended as an open or covert advocacy of a return to metaphysical methods and aims; but that, on the contrary, its tendency is throughout to eliminate from science its latent metaphysical elements, to foster and not to repress the spirit of experimental investigation, and to accredit instead of discrediting the great endeavor of scientific research to gain a sure foothold on solid, empirical ground, where the real data of experience may be reduced without ontological prepossessions. An attentive perusal of these pages will make it clear, I think, that this endeavor is continually thwarted by the insidious intrusion into the meditations of the man of science of the old metaphysical spirit. This fact having been established, it was incumbent on me to ascertain, if possible, its causes and, within the narrow limits at my command, to develop its consequences."

The first or introductory chapter of Judge Stallo's book is devoted to a statement of those theoretical ideas which are maintained to be fundamental in physical science. These involve the mechanical conception of the constitution of matter, or the atomo-molecular theory. A large number of the most authoritative writers are quoted, who agree that, in the language of Du Bois-Reymond, "the resolution of all changes in the material world into motions of atoms, caused by their constant central forces, would be the completion of natural science." The author sums up the doctrine as follows: "The mechanical theory of the universe undertakes to account for all physical phenomena by describing them as variances in the structure or configuration of material systems. It strives to apprehend all phenomenal diversities in the material world as varieties in the grouping of primordial units of mass, to recognize all phenomenal changes as movements of unchangeable elements, and thus to exhibit all apparent qualitative heterogeneity as mere quantitative difference."

The second chapter is devoted to an exposition of the general principles of the mechanical theory, which may be very briefly summed up in four propositions, as follows:

1. The elementary units of mass being simple, are in all respects equal.

2. They are absolutely hard and inelastic.

3. They are absolutely inert, and therefore purely passive.

4. All potential energy, so called, is in reality kinetic.

In the next six chapters these propositions are taken up in their order, with the view of ascertaining to what extent they are consistent with each other, and how far they serve as explanations of the facts of scientific experience. It here comes out that there is a profound anarchy in the views of the ablest scientists regarding ultimate scientific questions. Judge Stallo discusses the accepted theories with great critical skill and logical force, showing their short-comings and contradictions, and proving conclusively that what is now most needed is a thorough-going re-examination of the grounds of what is currently regarded as established scientific theory.

The eight chapters of the work to which we here refer are worthy of being very carefully studied on their own merits as expositions and criticisms of scientific theory. But the author's analysis brings out a group of errors, of which he finds it necessary to seek the sources and parentage. This opens to him (Chapter IX) the interesting problem of the relation of thoughts to things, the formation of concepts, and the consideration of metaphysical theories. He then passes, in Chapters X, XI, and XII, to an examination of the character and origin of the mechanical theory, and points out successively how it exemplifies four radical errors of metaphysics. The nature of these errors we have no space here to explain, but the author shows that they extend much further in their vitiating influence than to the mechanical theory of the constitution of material nature. In Chapter XIII he still further develops the general argument by explaining how the same metaphysical fallacies that taint our theoretical physics have given rise to modern transcendental geometry and the new doctrine of space, with four or more dimensions. In Chapter XIV this subject of meta-geometrical space is pursued in the light of modern analysis, and by an examination of Riemann's celebrated essay upon this subject. The further ramifications of metaphysical error in science are then followed out in Chapter XV into cosmological and cosmogenetic speculations, with a consideration of the nebular hypothesis. Chapter XVI concludes the work, with a summary of important portions of the previous discussion, and some further interesting reflections on the present attitude of chemical philosophy.

In regard to the atomic theory in chemistry, Judge Stallo does not deny its usefulness as a graphic device for representing chemical and physical transformations. He recognizes it as "a fact beyond dispute that chemistry owes a great part of its practical advance to its use, and that the structural formulas founded upon it have enabled the chemist, not merely to trace the connection and mutual dependence of the various stages in the metamorphosis of 'elements' and 'compounds,' so called, but in many cases (such as that of the hydrocarbon series in organic chemistry) successfully to anticipate the results of experimental research."

But the convenience of hypothetical devices can not prove their truth. In the advance toward higher science, erroneous views are often the efficient instruments of progression. The history of science is full of the utilities of erroneous theory. Early astronomy, as so well shown by Whewell, was mainly developed by the help of the false theory of epicycles. Experimental chemistry, as pointed out by Liebig, originated under the influence of the false notion of the transmutability of the metals; while its later advances were largely due to the erroneous hypothesis of phlogiston. So the atomic hypothesis has carried it on still further, but this no more proves it to be true than it did the preceding hypotheses. The scaffoldings of construction, important, indispensable as they may be, are not to be identified with the edifice.

This scanty outline of the author's argument will serve only to suggest the nature of the problems with which he is engaged. The book must be read deliberately, must be studied to be appreciated; but the students of science, as well as those of meta-

physics, are certain to be deeply interested in its logical developments. It is a timely and telling contribution to the philosophy of science, imperatively called for by the present exigencies in the progress of knowledge. It is to be commended equally for the solid value of its contents and the scholarly finish of its execution.

THE FRENCH REVOLUTION. By HIPPOLYTE ADOLPHE TAINE, D. C. L., Oxon. Translated by JOHN DURAND. Vols. I, II. New York: Henry Holt & Co. 1878, 1881. 8vo. $2.50 per vol.

Of the three volumes which are to complete M. Taine's "French Revolution" two are now published, continuing the study which was begun in his preceding work on "The Ancient Régime." The two works form parts of a continuous series, which the author calls "The Origins of Contemporary France." Of this extensive subject M. Taine says that he has limited his treatment, primarily, to the consideration of its governmental aspects. In the work he tells us: "There will be found only the history of public powers. Other historians will write that of diplomacy, of war, of the finances, of the Church; my subject is a limited one."

What are the themes of the two volumes before us? Briefly: the first shows how "popular insurrections and the laws of the Constituent Assembly end in destroying all government in France"; the second, how "a party arises around an extreme doctrine, gets possession of the power, and exercises it in conformity with that doctrine." That doctrine was found in the generalizations of Jean Jacques Rousseau. The philosopher who generalizes must forget a great many facts. In a vein of delicate irony M. Taine says of his countrymen: "Almost all of them, more fortunate than myself, have political principles which serve them in forming their judgments of the past—I had none; if, indeed, I had any motive in undertaking this work, it was to seek for political principles. Thus far I have attained to scarcely more than one, and this so simple that it will seem puerile. It consists wholly in this observation: that human society, especially a modern society, is a vast and complicated thing."

In this order of M. Taine's method; in this limitation to a definite aspect of the phenomena presented; in this avoidance of stock conceptions; and in this perception of the infinite differentiation of the phenomena—we may already perceive that we have come upon something quite different, in the way of written history, from anything that the merely literary method ever presented. M. Taine has spared no trouble to get his facts at first hand. "The most trustworthy testimony is that of the eye-witness, especially when this witness is an honorable, attentive, and intelligent man, writing on the spot at the moment and under the dictation of the facts themselves—if it be manifest that his sole object is to preserve or furnish information." In the national archives M. Taine has had access to a great amount of manuscript testimony of this sort. On the other hand, the Jacobin documents, infinite in quantity, the vast masses of "polemics planned for the needs of a cause," of "eloquence arranged for popular effect," are worthless, except as they show the character of their sources; and yet they must be examined. "Never has so much been said to so little purpose. The historian may read kilometres of it, but he rarely finds one fact, one detail of interest, one document which calls up in his mind a physiognomy, the actual sentiments of either villager or gentleman, a graphic picture of the interior of an hôtel-de-ville or a barrack, of a municipal council-chamber, or of the character of an insurrection."

How has M. Taine applied his methods to the facts thus garnered? In the first place, he has grouped the events of which he treats according to their causal relations, and often, therefore, in anything but the close sequence of dates. Nothing has puzzled his critics so much as this feature of his treatment: his book has been much the worst stumbling-block in the path of the routine reviewers, American and English, that has fallen in their way for years. M. Taine is not now writing a school-book, with a new date for each new paragraph: he is writing for readers to whom a formal knowledge, at least, of the most important crises in modern history is a matter of course. To recite dates in sequence is, indeed, not only the schoolmaster's idea of history: it

is the old, popular, easy way, which nearly all the English historians have followed until very recent times. In France, Montesquieu was probably the first great writer who saw that the schoolmaster's idea of history, as a series of dates, and the merely literary man's idea of history, like Carlyle's, as a succession of tableaux, were alike insufficient. Burckhardt, in his recent history of the "Italian Renaissance," seized the true idea; to discriminate, namely, the important lines of tendency in the given era, and to group the facts which bear upon each line, whether causally or consequentially. Burckhardt has pushed the method perhaps too far, making his work as much a group of essays as a history. But M. Taine keeps to clearly discriminable phases of the movements which made up the great Revolution; as indicated, for instance, in the book-divisions of these two volumes: I. "Spontaneous Anarchy"; II. "The Constituent Assembly"; III. "The Application of the Constitution"; IV. "The Jacobin Conquest."

We have dwelt thus long upon M. Taine's method because it is a feature which has been appreciated, so far as we know, by none of his critics in America—a country little given to historical studies; and, also, because that method is clearly associated with modern English philosophy. It remains to ask what M. Taine's conclusions are upon a theme which has occupied and baffled so many English historians before him.

As a visible thing the French Revolution began with the dearth of crops in 1788–'89. The "Reign of Terror" included the sixteen months from March, 1793, to July, 1794. The Revolution ended in October, 1795, with the suppression, by Napoleon, of the insurrection of the sections against the Convention. The present narrative includes the events of 1792. Under the old *régime*, two acres out of every five in France, as Voltaire expressed it, were in the hands of the clergy; and those two acres were generally the best of the five. A half of the peasant's earnings, or more, went to the church, the nobility, and the state. That was the substantial grievance which prepared the way for the Revolution. But other countries have had equally substantial grievances without any subsequent revolution. What, then, determined the Revolution of 1789?

By far the most important second cause, as a determinant, was a single book, Rousseau's "Contrat Social." That book was a triumph of the literary method in social science; it made the worse appear the better reason, and with such lucidity, such fatal persuasiveness, as even France had never known before. In a few words the orators—the mass of the people could not read—had made its principles familiar throughout France. The "Social Contract" defines the modern citizen by "eliminating the differences which distinguish a Frenchman from a Papuan, a modern Englishman from a Briton in the time of Cæsar. The resulting essence is very meager: it is 'a being with a desire to be happy and the faculty of reasoning'"—after Jean Jacques Rousseau. The French agitators consider the nation as composed of twenty-six millions of equal, free, and independent entities of this description, without obligations, institutions, or history; and free at any moment to make a social contract, *de novo*, of their own. Physical oppression, followed by this intellectual hallucination, disintegrated the most elaborate social structure of modern times. The fabric stood after it had lost the power to sustain itself, awaiting the first chance shock to topple it over. That shock was given by the failure of the crops in 1788, and the consequent half-starvation of the laboring-classes. The Revolution, begun in moderation, went rapidly on to madness; the power fell into the vilest hands. The general course of events is summarized in M. Taine's comparison as follows:

"A workman, overtaxed, in misery and badly fed, takes to drink. After a few years his nervous system, already weakened by spare diet, becomes over-excited, out of balance. An hour comes when the brain, under a sudden stroke, ceases to direct the machine; each limb, acting separately and for itself, starts convulsively. Meanwhile, the man thinks himself a millionaire, or a king; he sings and shouts; he drinks more than ever. At last his face grows dark; radiant visions give way to monstrous phantoms; he sees nothing but menacing figures, murderers ready to cut his throat. Then

he makes a spring: in order that he may not be killed, he kills. No one is more to be dreaded, for his delirium sustains him; his strength is prodigious. . . . So France, exhausted by fasting under the monarchy, made drunk by the drug of the 'Social Contract,' and other fiery beverages, is struck by paralysis of the brain. She is about to enter upon the period of somber delirium. Behold her capable of daring, suffering, and doing all, capable of incredible exploits and of abominable barbarities."

It remains only to add that Mr. Durand's translation aims primarily at accuracy, but that he has preserved much of the effectiveness, also, of M. Taine's vivid style.

THE HARROWGATE WATERS: Data, Chemical and Therapeutical, with Notes on the Climate of Harrowgate. By GEORGE OLIVER, M. D. London: E. Lewis. Philadelphia: Presley Blakiston. Pp. 224.

HARROWGATE is a kind of British Saratoga, having within a district of two miles eighty medicinal springs, no two of which are alike, and some of which are asserted to be, both from a chemical and from a therapeutical stand-point, unrivaled elsewhere. For these, and for certain climatal advantages ascribed to the place, it is claimed to be far superior to all other English health resorts. The volume, which is addressed particularly to medical readers, aims to give a scientifically correct account of the qualities of the waters, the diseases they are good for, and the most efficient methods of application.

REPORT OF THE COMMISSIONER OF EDUCATION FOR THE YEAR 1879. Washington: Government Printing-Office. Pp. 757.

THE commissioner is able to report a continually increasing demand upon his office for information, the present demand being greater than ever before. The multitude of details embraced in the report do not admit of collation into a paragraph, and we can only refer to a few isolated facts. The colored schools numbered 14,472, and their pupils 700,360, of whom 1,933 were college and 903 were professional students. Normal schools were established in all the States except Delaware, Florida, and Nevada; and they sent out during 1879 3,347 graduates. The Kindergartens were increasing, but under private enterprise, while the attempt to introduce them into the public-school system was attended with embarrassment. The condition of scientific and technical schools was promising; and the institutions, having excited the people to an appreciation of scientific methods and processes in their application to agriculture and the mechanic arts, were rising in favor. Regarding original investigations and publications by professors in American schools, the commissioner remarks that "it is a matter of just pride that our institutions are extending their activities in this direction, and that their publications and their positive contributions to the progress of science receive honorable recognition from the scholars of other nations."

MECHANICS' LIENS, HOW ACQUIRED AND ENFORCED. A Treatise referring to and citing the latest Statutes and Decisions, and designed for General Circulation among Lawyers, Builders, Mechanics, and Owners. To which is added an Appendix of Forms. By JAMES T. HOYT, of the New York Bar. New York: P. F. McBreen. Pp. 310. Price, $2.25.

THE subject of this book is of immediate interest to every property-owner and every workman, for every owner's property may become the object of a lien, and the workman of nearly every class may be in a position to hold a claim of that nature. It is therefore important to both classes to be able to know what a lien is, under what conditions it may exist, and what is the law relative to it. This the book aims to tell, as briefly as is possible consistently with giving a satisfactory statement. The author has examined more than a thousand legal authorities on the subject, and has arranged the whole mass of information which he has collected covering the whole case, so far as has been decided, in chapters, each of which covers a particular department. The points are presented briefly and clearly, and each one is enforced by a reference to the particular law or decision by which it is made effective. The work has been prepared with especial reference to the city and the State of New York, but the principles it embodies are of general application.

REPORT UPON UNITED STATES GEOGRAPHICAL SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN, in charge of First-Lieutenant GEORGE M. WHEELER, Corps of Engineers, U. S. Army, under the Direction of Brigadier-General A. A. HUMPHREYS, Chief of Engineers, U. S. Army. Published by authority of the Secretary of War. Vol. VII, Archæology. Washington: Government Printing-Office. Pp. 497, with 22 Plates.

THIS volume, which is put forth in a style and with a character of illustration worthy of the work to which it relates, and of the government under which the work is carried on, includes reports upon the archæological and ethnological collections from the vicinity of Santa Barbara, California, and from ruined pueblos of Arizona and New Mexico, and certain interior tribes, which have been prepared by Mr. Frederick W. Putnam, of the Peabody Museum, assisted by Drs. C. C. Abbott, S. S. Haldeman, A. C. Yarrow, and Messrs. H. W. Henshaw and Lucian Carr; and an appendix of Indian vocabularies, revised and prepared by Albert S. Gatschet. The vocabularies have been gathered from forty distinct localities, and are divisible into seven distinct stocks. The entire contribution represented by the book, says Lieutenant Wheeler, "has resulted from the incidental labors of members of several expeditions, and but points the way to a large and almost untrodden field of research among aboriginal remains."

ENGLISH HISTORY FOR STUDENTS: Being the Introduction to the Study of English History. By SAMUEL R. GARDINER, Hon. LL. D., Professor of Modern History in King's College, London. With a Critical and Biographical Account of Authorities, by J. BASS MULLINGER, M. A., St. John's College, Cambridge. New York: Henry Holt & Co. Pp. 424. Price, $2.25.

IN the first (Professor Gardiner's) part of this volume are considered the growth and development of English civil and political institutions from their origins; which origins, as the introductory chapter shows, are ultimately found at the beginnings of history. The principle is kept in view throughout that the bearing and meaning of every event are largely determined by the events that preceded it, and that it in turn exerts its influence on the events that follow. "By knowing this relation, the inquirer learns not merely what took place, but why it took place." Moreover, "the personalities of history are not merely figures flitting across a stage, of whom it is enough to learn the motives and the actions. They are themselves the result of causes which existed generations before they were born, and influence results for generations after they die." We can not, therefore, "study a generation of men as if it could be isolated and examined like a piece of inorganic matter," but must bear in mind that it is a portion of a living whole which is under observation. Professor Gardiner regards his part as really an introduction to Mr. Mullinger's account of authorities, which forms full half of the volume. It has been Mr. Mullinger's aim in this part carefully to distinguish the contemporary sources of information for each period from the sources of later times, and to supply, where practicable, such an amount of comment as will enable the student to form a fairly accurate notion of each author's value as an authority.

FIRST ANNUAL REPORT OF THE UNITED STATES GEOLOGICAL SURVEY TO THE HON. CARL SCHURZ, SECRETARY OF THE INTERIOR. By CLARENCE KING, Director. Washington: Government Printing-Office. Pp. 79, with Map.

THE present report reviews the operations of the survey during 1879–'80 in the four geological districts into which Mr. King has divided his work, and which are described in the text and clearly defined in the map as the divisions of the Rocky Mountains, the Colorado, the Great Basin, and the Pacific. Special attention is given to some particular feature or features in each district, so that the report may be regarded as consisting in large part of monographs on Leadville, Lake Bonneville, the Uinkaret and Grand Cañon districts of Colorado, and the San Francisco, Eureka, and Bodie districts of California and Nevada, and the Comstock Lode, each by the assistant geologist in whose particular field the subject fell. Information of a general character respecting mining resources and industries has been derived from officers of the Census Bureau, whose co-operation Mr. King enjoyed, and is added to the special

reports. A plea is made for the extension of the system of Government surveys over all the States—a step which political economists would deprecate, and which men of science are not disposed to believe would be of any real advantage to the cause they serve.

A MANUAL OF SUGAR ANALYSIS: Including the Applications in General of Analytical Methods to the Sugar Industry. With an Introduction on the Chemistry of Cane-Sugar, Dextrose, Levulose, and Milk-Sugar. By J. H. TUCKER, Ph. D. New York: D. Van Nostrand. Pp. 353. Price, $3.50.

THIS book supplies a want, there being no work in English that treats of sugar analysis, and only a few scattered and incomplete dictionary articles. Yet a great amount and variety of analytical work are required for the various interests connected with sugar, and it is not always convenient for the chemist to have to depend upon German and French treatises, numerous and good though they may be. The author, in endeavoring to fill this gap in chemical literature, has brought the matter up to the present time, and believes that he has given fuller treatment to some points than can be found elsewhere.

BOOK OF THE BLACK BASS: Comprising its Complete Scientific and Life History, together with a Practical Treatise on Angling and Fly-Fishing, and a Full Description of Tools, Tackle, and Implements. By JAMES A. HENSHALL, M. D. Fully illustrated. Cincinnati: Robert Clarke & Co. Pp. 463. Price, $3.

THE author is regarded as an authority on the black bass, and is an expert angler. He has apparently embodied in this volume all the lore on the subject, giving the color of justice to the publisher's assertion that it is the most complete and exhaustive monograph ever published upon any game-fish. The fish itself deserves the most respectful treatment, for it is a game-fish of the highest order, is pre-eminently American, inhabits the whole United States east of the Rocky Mountains, except New England and the Atlantic waters of the Middle States, and is found also in Eastern Mexico. Its scientific treatment has hitherto been unsatisfactory, for different authors have not been able to agree as to whether there should be two or four or more species, in what the specific differences should consist, and what the names should be. The author gives one hundred and thirty-two pages to the consideration of what has been written on this subject, and adds his own views that there are two species, the large-mouthed (*Micropterus salmoides*) and the small-mouthed (*Micropterus dolomieu*), which are apt to sport into indefinite varieties. He gives his own descriptions of the fish and its habits, and fills half the volume with descriptions and suggestions respecting bass-fishing tackle, and the methods of fishing.

AN ARTISTIC TREATISE ON THE HUMAN FIGURE: Containing Hints on Proportion, Color, and Composition. By HENRY WARREN, K. L., author of "Artistic Anatomy," etc. Edited by SUSAN N. CARTER, Principal of the Woman's Art School, Cooper Union. New York: G. P. Putnam's Sons. Pp. 82. Price, 50 cents.

A MANUAL of suggestions, adapted to practical application, in one of the most important departments of art. The author seeks to point out errors in the present systems of drawing the figure—errors arising out of unconsidered conditions of placement and pose; to explain what is natural and what is merely conventional. Color and *chiaro-oscuro*, handling and manipulation, are touched upon. Generally, enough is attempted to set the student thinking upon the best means of economizing the time which he has at his disposal.

THE WANDERING JEW. By MONCURE DANIEL CONWAY, author of "Demonology and Devil Lore." New York: Henry Holt & Co. Pp. 292. Price, $1.50.

MR. CONWAY in this work considers the legend of the Wandering Jew in all the forms which it has assumed in different countries. As reasons for undertaking the work he offers: no other treatise on the same subject exists in our language; in the pamphlets that have appeared in other languages, the relations of the legend with Eastern mythology have been little considered, and its connection with Hebrew and Christian mythology almost ignored; and those studies of it which he has read consider it mainly as a curiosity. "But the

subject," he adds, "as it appears to me, possesses a larger significance. Even the poems and romances it has suggested fail to render the still, sad music of humanity pervading the variations of the folk-tale itself." He regards the legend as a kind of a mirror, "wherein may be seen by reflection things that few eyes can look upon directly"—among them an aspect in which Christianity has appeared to believers of former generations. From the immediate subject he is led to a consideration of the character, condition, and probable destiny of the Jewish race and religion.

AN INTRODUCTION TO THE SCIENCE OF COMPARATIVE MYTHOLOGY AND FOLK-LORE. By the Rev. Sir GEORGE W. COX, Bart., M. A., author of "Popular Romances of the Middle Ages," etc. New York: Henry Holt & Co. Pp. 380. Price, $1.75.

THE purpose of this volume is to give a general view of the vast mass of popular traditions belonging to the Aryan nations of Asia and Europe, and of other tribes so far as the conditions of the subject may render necessary. Its starting-point, says the author, is the principle that "the popular traditions of no one Aryan people can be really understood except in their relations to those of other tribes and nations of the same family, and that the epical and dramatic literature of these races has been constructed from materials common to all branches of the Aryan stock, and furnished by popular sayings, stories, and tales, many of which have never had the good fortune to be more than the talk of nurses and children." An immense number of stories are condensed or referred to in illustration of these views.

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Primer of Logical Analysis for the Use of Composition Students. By Josiah Royce. San Francisco: A. L. Bancroft & Co. 1881. Pp. 77.

The Stereoscope and Vision by Optic Divergence. By W. Le Conte Stevens. From the "American Journal of Science," November and December, 1881. Pp. 14. Illustrated.

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The Origin of Primitive Superstitions. By Rushton M. Dorman. Philadelphia: J. B. Lippincott & Co. 1881. Pp. 398. $3.

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Suicide: Studies on its Philosophy, Causes, and Prevention. By James J. O'Dea, M. D. New York: G. P. Putnam's Sons. 1882. Pp. 322. $1.75.

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Report on the Geology and Resources of the Black Hills of Dakota. With Atlas. By Henry Newton, E. M., and Walter P. Jenney, E. M. Washington: Government Printing-Office. 1880. Pp. 566.

## POPULAR MISCELLANY.

**Value of Soil Analysis.**—Professor E. W. Hilgard, in a paper in the "American Journal of Science," on "The Objects and Interpretation of Soil Analyses," accepts as correct the principle that, other things being equal, productiveness is, or should be, sensibly proportional to the amount of available plant-food within reach of the roots during the period of the plant's development, provided that such supply does not exceed the maximum of that which the plant can utilize, when the surplus simply remains inert. For finding the exact value of the soil from analysis, it is necessary, however, not so much to find the actual amounts of the constituents in the soil, as to find the amounts which are accessible to and assimilable by the plants. The problem is, then, to find a solvent which shall as nearly as possible represent the action of the plant itself. Analyses of European soils fail because virgin soils do not exist in Europe, and no generalizations can be drawn from the examination of any spot. In the United States we still have perfectly natural soils in nearly every part of our territory, with the original vegetation, which reveals so much to the farmer, still growing upon them. Professor Hilgard's method of analysis starts from the observation of the productive qualities of the soil as indicated by the native growth. He then tries to ascertain what are the peculiarities of the soil that favor this kind of growth, as distinguished from some other growth on some other soil. As a rule, a soil showing a high percentage of plant-food is fertile; but the converse is not always true; a soil having a low percentage is not necessarily poor. A loose soil, by enlarging the sphere of expansion of the roots may enable them to reach as large quantities of food, even when it is more widely scattered, as they can find in a more highly charged but more compact and less penetrable soil. Hence mechanical conditions should always be taken into account. The analyses so far instituted prove that, other things being equal, the thriftiness or present productiveness of a soil is measurably dependent on the presence of a certain minimum quantity of lime. The evidence on this point is "overwhelming." The lime operates by effecting the more rapid transformation of vegetable matter into active humus, by retaining the humus against the oxidizing influence of hot climates; by rendering minute percentages of phosphoric acid and potash effective; by a tendency to secure the proper maintenance of the conditions of nitrification; and, physically, by promoting the flocculation of the soil. After that of lime, the proportion of phosphoric acid seems to be the most important factor in the productiveness of soils. A certain percentage of potash is required, but it is present in most soils; and Professor Hilgard infers, generally, that "potash manures are not among the first to be sought for after the soils have become 'tired' by exhaustive culture." Iron, in the shape of ferric hydrate finely diffused, appears to be an important ingredient, valuable on account of its physical, and partly also of its chemical qualities. It has a high absorptive power for gases, and soils in which it occurs resist drought better than others; and the universal preference given by farmers to red lands shows the results of experience in this respect. The efficiency of the hydrate depends essentially upon a state of fine division; and when merely incrusting the sand-grains, or aggregated into bog-ore grains, it exerts little or no influence, although the analysis may show a high percentage. On the other hand, ferruginous soils are the first liable to damage from imperfect drainage, overflows, etc.

**The Eocene Strata of Alabama.**—Mr. Angelo Heilprin has communicated to the Academy of Natural Sciences of Philadelphia an effort to arrange the Eocene deposits of Alabama, determine their depth, and fix their relative position in the geological system. For this purpose he has given comparative reviews of the examinations of various exposures, including the Claiborne Bluff and sections on Bashia Creek, Clarke County, and at points on the Tombigbee River. The Claiborne Bluff was formerly considered to be near the base of the Eocene system, but it appears to be underlaid by the strata which crop out at other points, indicating a thickness of at least 200 feet, if not more, of Eocene de-

posits beneath it, and a total thickness for the whole system in this region of nearly 400 feet; indeed, Dr. Smith, the State geologist, states that there are good grounds for supposing that tertiary beds exist in the northern part of the State, whose position would be 150 to 180 feet below the Wood's Bluff marl-bed, which is near the base of the Tombigbee beds. The Claibornian bed would then be placed in a position near the top of the series, a position almost precisely similar to that occupied by the Calcaire Grossier (Parisian) of France, and more properly Upper than Middle Eocene. The Alabama Eocene deposits are arranged on this scheme by Mr. Heilprin as follows: 4. "White Limestone" (Jacksonian), but exhibited at Claiborne (upper part of bluff) and at St. Stephen's on the Tombigbee (lower half of bluff), not very abundant in fossils, 50 or more feet; 3. The fossiliferous arenaceous deposit (Claibornian), but shown at Claiborne—subaqueous at St. Stephen's—very rich in fossils, and of the age of the "Calcaire Grossier" of France, 17 feet; 2. Buhrstone (siliceous Claiborne of Hilgard), comprising siliceous clay-stones densely charged with fossils or their impressions, laminated clays, sands, and calcareous deposits, about 250 or more feet; 1. The Wood's Bluff and Bashia deposits (with Cane and Knight's Bluff branches) (Eo-lignite), consisting of alternating dark clays, greenish and buff sands, and numerous seams of lignite, partly very rich in fossils, and, as far as is yet positively known, the oldest tertiary deposits of the State, 50 or more feet. The author intends to discuss in a future paper the relations of these deposits to those of other parts of the United States, and to correlate them, if possible, with the typical Eocene deposits of Europe.

**Australian Snakes.**—A correspondent of "Land and Water" relates some interesting particulars concerning Australian snakes and their peculiarities. Among the largest is the carpet-snake, or boa, which grows to be ten or a dozen, even eighteen feet long, and as thick as a man's leg, is destructive to poultry, sluggish by day, nocturnal in its habits, and of harmless bite. Most of the black snakes are highly venomous, and one, with a scarlet belly, is very handsome and active. The color of snakes depends upon the season when they change their skins. During the hot season the reptile is far brighter in tint, and far more active and poisonous, than when the temperature is low. The color also varies much with the habitat. Thus, the death-adder is nearly red in a red-soil country, black and gray in black soil, and brown on sand, and is exceedingly sluggish, trusting to the adaptation of his color to the ground he crawls upon for safety. Nothing is more remarkable about snakes than their extraordinary faculty of making themselves invisible. A large carpet-snake can hardly be seen, as he lies along a branch or coiled motionless in the fork of a tree whose bark exactly matches his skin in color. The green tree-snakes are invisible among foliage. "Take your eye for a moment from a snake among bushes or grass, and you will hardly ever see him again." Two yellow snakes lived in the correspondent's house, among the rafters or in the linings of the walls, where their presence was known by the casts of their skins which they left, for two years, without being seen or heard. Evidence of the existence of great numbers of unseen snakes is afforded by the multitude of tracks, which may be seen in the dust of a road following along a water-course. Snakes seldom advance to attack a man, but generally try to get away from him, and go toward him only when he is between them and their place of refuge. The Australian snakes, even the most venomous, can not fairly be called dangerous. The correspondent never knew personally of a case of a bite fatal to human life, though he has often seen the reptiles coil themselves round the legs of horses and bullocks, "with strong presumption in every case of a bite," but never knew of any injurious result. Many cats and dogs, however, learn to kill snakes, "but almost always end by missing their tip once, and fall victims to over-confidence in themselves"; and the blacks eat all sorts, whether venomous or not, provided they kill the former kind themselves.

**Hawaiian Leprosy.**—Dr. A. W. Saxe has lately made a report to the California State Medical Society on leprosy in the Hawaiian

Islands, which is partly based on observations made during a visit to the leper settlement on the Island of Molokai in February, 1880. The Hawaiian leprosy does not differ essentially from the disease in Europe and Asia, but its history is known from its origin, and its development there may be traced with greater accuracy of detail than in other countries. It was introduced from China with the coolie-trade, and was first recognized in 1848. Its spread has been furthered by the peculiar habits of the people, particularly in eating, and their close association in their houses, and is contributed to by the exhaustion caused by the use of the intoxicant *kava*. To this may be added impure vaccination, which was practiced indiscriminately by all classes of people in 1852, and the prevalent licentiousness, which is hardly concealed. All observers agree that the disease is hereditary and that death alone ends it. It is established that it is a specific and well-marked disease—not a form of syphilis—that it exists in two varieties, the tubercular and anæsthetic, which may be distinct or associated, that it is not contagious, but is transplantable, and that men are more liable to it than women. The treatment has heretofore been merely palliative, the most useful drug in affording relief being the bark of the hoang-nan-tree. The most effective preventive of the spread of the disease is isolation. Few of the children born of leprous parents survive infancy and none survive adult age. Hence, is suggested the possibility of stamping it out if the lepers can be kept separated from the rest of the population. The population of the Pacific States are in no immediate danger from leprosy, but the increasing intercourse with China and the Sandwich Islands, combined with prostitution, offers a constant menace, and makes vigilance a duty.

**The Real Discoverer of Spectrum Analysis.**—Mr. Frank Cowan makes, in the "Pittsburg Telegraph," a strong presentment of the claims of the late Dr. David Alter, of Freeport, Armstrong County, Pennsylvania, who died last September, to be regarded as the real discoverer of spectroscopic analysis. Dr. Alter was born in 1807, and manifested at a very early age an interest in the study of electrical phenomena, and later in chemistry. He invented and perfected an electric telegraph in 1836, which, being more cumbrous than Morse's, and even than Wheatstone's, he never attempted to bring into use. He also invented an electrical engine, and published a paper on electricity as a motive power in 1837. His papers on spectrum analysis were published in the "American Journal of Science" in 1854 and 1855, five years before Kirchhoff announced his discoveries. The first paper, published in the number of the "Journal" for November, 1854, was "On Certain Physical Properties of Light, produced by the Combustion of Different Metals in the Electric Spark, refracted by a Prism." After describing the appearance of the light of the sky, of a petroleum-lamp, of a tallow-candle, the flame of alcohol, and the light from heated wire or charcoal as seen through his home-made prism, he gives accounts of the "separate colored bands" which he observed in the spectra of the sparks caused by the break of the galvanic or magneto-electric circuit, from points of silver, zinc, copper, lead, tin, iron, bismuth, antimony, brass, and combinations of metals. The second article appeared in May, 1855, and was "On Certain Physical Properties of the Light of the Electric Spark within Certain Gases, as seen through a Prism." This paper is explicit, and contains a paragraph suggesting the application of the author's discovery to the detection of the elements in the aurora borealis, shooting-stars, and luminous meteors. An abstract of the first paper was published in Liebig and Kopp's "Chemico-Jahresberichte" for 1854. The second article was reproduced entire in "L'Institut," of Paris, in 1856, and in the "Archives of the Physical and Natural Sciences" of Geneva, vol. xxix, p. 151. A full-page extract from it, containing its most suggestive statements, was also published in Kopp and Will's "Jahresberichte" for 1859. Kirchhoff announced his discovery in the year last mentioned.

**Organic Remains in Meteorites.**—Professor J. Lawrence Smith expresses a strong disbelief in the alleged discovery by Professor Hahn of organic remains in meteoric stones. He says that, although he has probably examined more microscopic plates of

fragments of meteorites than any other person, he has never discovered anything like organic remains in any of them. Besides, he adds, "the well-known chemical composition of these bodies is averse to the existence of any such remains as are spoken of by Professor Hahn. Were these remains present, we should discover carbonate of lime in their interior. The two or three that have any carbonate of lime were discovered and analyzed by myself, and in those cases the carbonate of lime was an accidental constituent of incrustation deposited on the surface after their fall. In the microscopic examination of the polished plates of meteorites the two predominating minerals, enstatite and bronzite, will, by their fissures and forms, sometimes remind one of vegetable and other organic forms, but the merest tyro of an observer will trace here nothing but a rare resemblance. And, furthermore, the very igneous nature of these minerals precludes the possibility of organic remains, even in terrestrial minerals of a similar kind. Professor Hawes, of the Smithsonian Institution, who is familiar with lithological microscopical researches in Germany, agrees with Professor Smith, describes Professor Hahn as an observer whose "imagination has run wild with him," and regards his observations as not entitled to credit.

**Obituary.**—American science has lost during the last month two of its most distinguished names. Lewis H. Morgan, the anthropologist, died at his home in Rochester, New York, December 17th, of a complication of disorders, from which he had suffered for several months, at the age of sixty-three years. We have recently (November, 1880) given a sketch of his life, and his principal investigations and writings. His fame has been growing and the influence of his ideas extending for many years; and it has long been usual to see him quoted as an authority whose views were entitled to the highest respect, even when dissented from, in the anthropological discussions of all nations. Professor John William Draper, M. D., LL. D., died at Hastings-on-the-Hudson, January 4th. He was born near Liverpool, England, May 5, 1811, came to the United States in 1833, was graduated in medicine at the University of Pennsylvania in 1836, and began the connection as professor with the University of the City of New York in 1839, which he maintained till the end of his life. He assisted in founding the medical department of the university in 1841. He was closely identified with the progress of chemical science in the United States, particularly in connection with the investigation of the chemical action of light, and of the temperature of incandescence, and in the early history and development of photography. His most noteworthy works were his treatise "On the Forces which produce the Organization of Plants," which marked an epoch in this branch of investigation, and his "History of the Intellectual Development of Europe," which has been translated into nine languages. He also published books on "Human Physiology, Statical and Dynamical; or the Conditions and Course of the Life of Man," "Thoughts on the Future Civil Policy of America," the "History of the American Civil War," and a "History of the Conflict between Religion and Science," all of which have made their mark; and text-books in chemistry and natural history. A fuller account of Professor Draper's life and works is given in the "Popular Science Monthly" for January, 1874, and frequent references to his later labors may be found in subsequent volumes.

**Influence of the Electric Light on Plant-Life.**—M. P. P. Déhérain has just published the results of the experiments he conducted during the Exposition of Electricity at Paris, on the influence of the electric light upon vegetation. A conservatory was built within the palace, in which plants were disposed in four groups, each receiving a different treatment. One group was deprived of the light of day and was exposed to the electric light all the time; another had the diffused daylight, weakened by having to pass through the glass roofs of the Exhibition Palace, by day, and the electric light at night; a third group had only the diluted daylight by day and was left in the dark at night; and the fourth group, kept during the day in a shaded garden-bed, and was taken into the conservatory and exposed to

the electric light at night. Some plants, which were taken into the conservatory a few days before the electric apparatus was put in operation, suffered badly from the deficiency of light—much more than the experimenter had anticipated they would. The plants that were constantly exposed to the electric light became marked with spots, and began in the course of eight days to give evidence of having received serious injuries. That the spots were caused immediately by the light and not by the disengagement of nitrous vapors, was shown by the fact that only the leaves and parts of leaves that were exposed directly to the light were touched. This satisfied M. Déhérain that the electric light contains rays that are detrimental to plant-life; and the facts indicate that these rays are the violet ones. A direct trial of the capacity of the electric light to decompose carbonic acid was made, with the result that less gas was evolved from plants continuously exposed within twelve feet of the light for several days than is given out in an hour in the sunlight. Plants that enjoyed the light of the conservatory by day and received the electric light at night, suffered less, but were not healthy. The electric light was inclosed in globes of transparent glass and a new set of experiments was instituted with new plants. The mischievous effects of the violet rays were no longer perceived, but the light was not capable of maintaining a healthy growth. The plants started well, but sent out long, thin shoots, which withered and died. Nothing but barley reached a condition near maturity. None of the plants would bloom; but some of them died at the top and took a new start from the root—to wither and die again. Continued experiments showed that these results were due to the lack of power in the electric light to promote the activity of evaporation required to bring the plants to maturity. The plants that were kept in the weakened, diffused light of the conservatory by day, and in the dark at night, fell into a gradual decay. Those that spent the day in the shade out-of-doors, and the night under the electric light, did better, but not much better, than they would have done if they had been left undisturbed out-of-doors. M. Déhérain concludes that the electric light has sufficient power to keep plants alive that would die in the dark, and that it exerts enough positive influence upon vegetation to account for the seemingly favorable results of M. Siemens's experiments, in which vigorous plants that had the light of day, and would have done well anyhow, were made to do better by being given also the electric light at night.

**Word-Blindness.**—M. Magnan, in a communication to the Société de Biologie, has related two cases of aphasia complicated with a special phenomenon, to which he has given the name of word-blindness. One case was that of a man who was seized with a right hemiplegia and aphasia after a fall. A month afterward, the patient recovered the power of speech, little by little: he understood spoken language; he wrote, of his own accord or from dictation, but was incapable of reading either print or manuscript, even when the latter had been written by himself; and he could not name letters written upon a board. The second patient presented similar symptoms. He recognized objects which were shown him, but could not name them; could write words thought or heard, but could not comprehend what was written. He had lost the notion of the value of gesticulations. A similar case is reported by M. Brunardel, in which a *post-mortem* examination revealed a disordered condition adjoining the pli courbé. The pathology of the affection is explained by supposing that the communications between the psychic visual center, which is situated about the pli courbé, and the convolutions of Broca, are interrupted. In such a case, the patient can still see, speak, and hear, but can not acquire any new idea through his eyes. "Brain" suggests that since no disease of the eye exists, and the affection is owing to a purely psychic phenomenon, it might be better described as "cerebral word-blindness."

**Death of Dr. J. B. Davis.**—Dr. Joseph Barnard Davis, an eminent British authority on skulls, died in May last, at about eighty years of age. He made a voyage to the Arctic regions as surgeon to a whaling-ship in 1820, while still a medical student, then settled down in the potteries of Staf-

fordshire as an apothecary. An accidental conversation with a friend turned his attention to anthropological studies, on which he published several memoirs, more particularly relating to the craniological branch of the subject, the most important of which was perhaps the "Crania Britannica," containing delineations and descriptions of the skulls of the aboriginal and early inhabitants of the British Islands. He was an industrious hunter after specimens, and formed at his house a collection of crania and skeletons larger than the collections in all the public museums in the country put together, and which has been surpassed only in very recent years by any of the Continental collections. The catalogue of this collection, the "Thesaurus Craniorum," published in 1867, contains descriptions and many figures of the specimens, with twenty-five thousand measurements and a large fund of information. The collection was so much increased afterward that a supplement to the catalogue was published in 1875. The two works contained descriptions of seventeen hundred specimens. The collection has been transferred to the College of Surgeons of England.

**Congresses of German and Austrian Archæologists.**—The Twelfth Congress of German Archæologists met at Regensburg, August 8th, the members having, previous to assembling, visited a local collection of prehistoric and Roman antiquities, illustrating the history of the settlement of the Danube for two thousand years, and listened to an address by Professor Fraas, on the geology and history of Regensburg from its beginning. The report of the general secretary, Professor Ranke, gave a summary of the general progress of archæological science during the year, and referred especially to the exhibition at Berlin, and the publications connected with it, as having increased interest in the science; to Professor Fraas's review of the primitive history of the country in the Stuttgart catalogue; to the results of the Congress at Lisbon, and to the evidence that had been found, in the Iberian Peninsula and Hungary, of a distinct copper age forming a transition to the bronze age. The list of special publications was quite full, and included essays by Tischler, Voss, and Virchow, on sewing-needles, belt-clasps, treasures, and urns; of Liebe on a former submergence of Thuringia; of Mehlis on the discoveries at Kirchheim on the Eck, and the Hermundurs and Thuringians; of Rosenstein on the spread of flints through trade; of Fischer on the traffic in nephrite; of Oehlenschläger and Herzog on the cartography of the discoveries in Bavaria and Würtemberg, and of other writers on single objects of prehistoric research. The study of local names had been advanced by the labors of Buck in Swabia and Schulenberg in Brandenburg, and Voss has made special studies on formulas of incantation and the blessing of swords. Herr von Tröltsch exhibited a series of four elaborate maps of the archæological discoveries in Schleswig-Holstein, in which the several classes of rocks and relics were very distinctly indicated by colors. Professor Schaafhausen reported, upon the progress of the general catalogue of the anthropological material of Germany, that special catalogues of the collections in the principal cities and universities are already completed or in hand, and those of societies and private persons will be taken up next. After spending three days in listening to a series of interesting papers, the members of the association went to Salzburg to meet with their fellow-workers of the Austro-Hungarian Association. The sessions here were more lively, and were marked with greater interest than those at Regensburg, for they were characterized by free discussions of every topic, while the proceedings at Regensburg were confined to the reading of the papers. Count Gundiken Wurmbrand, President of the Austro-Hungarian Association, delivered the opening address, referring chiefly to the Etruscan relics found in Austria, the evidences of Celtic culture on the Danube, and the significance of popular ethnography in prehistoric research. The first day's session was occupied with a very lively discussion of the "Celtic question," that is, the question whether the later Germans were ethnologically identical with the earlier Celts, or whether the two were distinct stems. Other interesting discussions were those concerning the period of the mammoth, and concerning the diluvial human relics found in Stramberg. The reports of the German society stated that it now in-

cluded fifty-eight local unions or groups, and about twenty-three hundred members.

**Development of the Mammalian Foot.**—Professor E. D. Cope has suggested as a result of his studies of the feet of the mammalia, that the reduction in the number of toes in the ungulates "is due to the elongation of those which slightly exceeded the others in length, in consequence of the greater number of strains and impacts received by them in rapid progression, and the complementary loss of material available for the growth of the smaller ones. This is rendered probable from the fact that the types with reduced digits are dwellers on dry land in both orders, and those that have more numerous digits are inhabitants of swamps and mud." The cloven-footed animals were mud-dwellers, as a few of them still are, and larger than the whole-footed ungulates; and "the mechanical effect of walking in the mud is to spread the toes equally on opposite sides of the middle line. This would encourage the equal development of the digits on each side of the middle line, as in the cloven-footed types." On the other hand, in progression on hard ground, the longest toe (the third) will receive the greatest amount of shock from contact with the earth, and there is every reason to believe that shocks, if not excessive, encourage growth in the direction of the force applied. The hinge between the first and second series of tarsal bones in cloven feet is also supposed to be the result of strains endured in walking in mud. The variations in the degree of development of the trochleæ, or the prominences forming the tongues of the tongue-and-groove articulations, in different mammalia, also seem to be dependent on the amount and kind of strain to which the limbs are subjected.

**The Archæological Congress at Tiflis.**—A very interesting Archæological Congress was recently held at Tiflis, which was attended by about eight hundred persons, nearly all from Russia and the Caucasus. Professor Virchow was the most conspicuous foreign delegate. Collections of stone and bronze antiquities and Georgian ornaments were exhibited from Russia, Kuban, and Ossetia, where great numbers of bronze implements, carved hatchets with spiral, zigzag, and animal ornaments, and religious objects belonging to some unknown worship, have been found in recent years. Count Ouvaroff made a communication on remains of the stone period—human skeletons, with stone and bone implements, perforated teeth of animals, and as many as two hundred jade (nephrite) hatchets, the first jade implements observed in graves in Russia, which had been found on the bank of the Angara River, near Irkutsk. In the discussion concerning jade that followed the reading of this paper, M. Moushketoff described the great monolith of jade over the grave of Tamerlane at Samarcand, which is 7·8 feet long, 1·5 foot wide, 1·2 foot high, and weighs about eighteen hundred pounds, or more than twice as much as the largest pieces of nephrite that have been found in bowlders. Professor Samokoff gave an account of his finds in the graves near Pyatigorsk, in the Caucasus. He excavated about two hundred graves belonging to the stone, bronze, and iron periods, and found in the larger graves bronze and stone implements, bones of sheep, and several split human bones that did not belong to skeletons. His conclusion that the Caucasians of the bronze age were anthropophagists was not concurred in by the majority of the Congress. Professor Virchow gave a lecture on the chief problems of the ethnology and archæology of the Caucasus. On the current opinion that the Caucasus was the highway for populations coming from Asia to Europe, he expressed some doubts whether the Caucasian passes could have been crossed by whole tribes at a time when communications were so difficult, and the ice-covering descended lower than now. It would be most important, therefore, to ascertain whether the first inhabitants of the Caucasus came from the north or from the south. He considered that the civilization which the antiquities found in Ossetia represent was far more recent than that discovered by Dr. Schliemann at Troy.

**Acoustics in Architecture.**—Mr. A. F. Oakey, the architect of the Cincinnati Music Hall, gives some valuable suggestions on "Acoustics in Architecture" in "Van Nostrand's Engineering Magazine." The most essential requisite to a good music hall or

hall for public speaking is, that it should be, as to its dimensions, in harmonic proportions. By this is meant that the length, breadth, and height of the room should bear some simple, easily determinable proportions to each other; generally one corresponding with the commensurate ratio borne by the intervals between the tones of the musical scale, which is expressible by the numbers from one to six. Harmonic proportions may be represented by the combinations 6 : 2 : 3, 6 : 5 : 3, 2 : 5 : 3, 2 : 2 : 4, 2 : 3 : 4, or others as simple. Angles, being a disturbing element, may be obviated by adopting curved surfaces, but these must not be circular, for we should then have a whispering gallery, nor elliptical, for then the sounds would be concentrated in the foci; but they should be in the shape of a parabola having its focus very near the contour. The seats should rise toward the back of the room, to correspond with the tendency of the sound to rise with the ascending currents of air, and to prevent its being caught in the clothing of the audience. A system of ventilation should be adopted that will rather carry the sound toward the audience than in the other direction. When the amount of space for each person exceeds one hundred and ninety-five cubic feet, the walls and ceilings should be finished with resonant material; where the amount of space is less than this, the finish should present a repellent, hard, and unsympathetic surface like plaster, or like stone if the space is less than one hundred and fifty feet. The obstructions presented by the supporting-posts and the acute angular recesses of galleries may be avoided by constructing the gallery upon a system of curved iron supports beginning on the floor-line against the wall and rising with a gradual parabolic curve outward, the spaces between which should be filled in with wood or plaster surface. In the light of these principles, Mr. Oakey can "see no excuse for building an apartment so that its acoustic properties shall not be as much a matter of course as keeping out the weather." Mr. Oakey also considers the sonority of party-walls, for which he suggests furring, with lathe and plaster and the removal of the bearings of floor-joists from the walls, as cheap and efficient remedies.

**Heat and Health.**—A sufficiency of heat is one of the most essential requisites to health; and in the administration of heat we have one of the most powerful curative agents. The sun furnishes a constant supply of beneficial warmth, of which we make much less use than we might and ought. Indeed, we too often shun that which we ought to seek, as when we deliberately and at considerable cost darken the rooms into which we ought to welcome the sunshine, or carefully exclude its life-giving rays with umbrellas and parasols. The idea of a sun-cure, which was proposed by one of our physicians several years ago, was one of genuine merit, and has been strongly commended, after several years of observation in the East, by the late Mr. David Urquhart, M. P., and secretary to the British embassy at Constantinople, who has related many incidents illustrating its efficacy. Among them was that of a person who had been advised, at the baths of Gastein, to try air-baths in the neighboring forests. He received considerable benefit from lying undressed in the shadiest part of the forest, but finally concluded to expose himself in the full sunshine. Although he had always supposed that the rays of the sun gave him headache and derangement of the stomach, he found that when entirely exposed he was not unpleasantly affected in any degree, but felt agreeable sensations of genial warmth. If, however, he covered any part of his body, the disagreeable feelings returned, and the covered part became intolerably hot. Occasionally a pricking and itching sensation and redness of the skin suggested the suspension of the baths for a day or two. Dr. Scanzoni, of Wurzburg, explains the freedom under these baths from the pains in the head and stomach which commonly follow exposure to the sun by the fact that the action is diffused equally all over the body, and the circulation is determined in a corresponding manner, instead of being drawn in excess to the head. Dr. Gosse, of Geneva, wrote in 1826 in high praise of the curative properties of heat, which he regarded as working by restoring the action of the skin. The hot-air bath has been used for twenty years in the Newcastle Infirmary with satisfactory results, and has been introduced into several luna-

tic asylums with most excellent effects in soothing and curing mania and the attendant diseases. Dr. Lockhart Robertson, of the Sussex County Lunatic Asylum, not only recommends it in those cases, but says that he has had several examples of its curative power in the early stages of consumption, and believes that, if used at a sufficiently high temperature, the results would astonish us all. Mr. Urquhart observes that a high temperature is more endurable when the heat is radiant than when it is brought in hot air-currents.

**Association of German Naturalists and Physicians.**—The fifty-fourth meeting of the Association of German Naturalists and Physicians was held at Salzburg, September 18th to 24th. The first secretary of the association, Dr. Günther, of Salzburg, in his address of welcome, mentioned the fact that Salzburg was the last place of retirement of Paracelsus; and that great physician and naturalist was the subject of a special address by Dr. Kirschensteiner, of Munich, at the closing session. The meeting was divided into twenty-three sections, eleven of which were medical, and seven pertained to natural science. Besides Professor Pettenkofer's paper on the sanitary relations of the soil, which we publish, Professor Weisman read a paper maintaining that in general the duration of life of an individual represents the minimum of time necessary to insure the existence of the species, and is governed by adaptation and heredity. Professor Meyners, of Vienna, in an address on the laws which govern human thoughts and actions, expressed the opinion that the phenomena of bodies do not disclose to us their essence, and that there is only a phenomenon of freedom of will. At the third general meeting, Professor Oppolzer, of Vienna, disputed the sufficiency of the theories of the moon, Mercury, and Encke's comet, based upon Newton's law of gravitation in its present form, and postulated the hypothesis of a cosmic matter surrounding the sun as necessary to complement them and make them sufficient.

**Animals and the Telegraph.**—M. Nielsen, director of the Norwegian telegraph lines, has just published a curious note upon the impressions that are produced upon animals by the vibrations of telegraphic wires. The posts in the neighborhood of the Norwegian pine-woods, even those which have been freshly impregnated with sulphate of copper, are frequently found to have been perforated by woodpeckers, which, it seems, mistake the humming of the wires for the buzzing of insects. The holes are generally made near the insulators, and a post shown at the Paris Electrical Exhibition had a hole clear through it large enough to insert the whole arm. Bears imagine the humming to be that of bees, and, not finding any sign of a colony above, paw at the heaps of stones at the base of the poles; and, when they can find nothing, vent their spite in a vigorous blow on the ground, to kill the bees that persist in staying hid. The scattering of the heaps of stones around the posts, which is not rare, could not be explained, till some one perceived the marks of the bears' claws where these desperate blows had been given. Wolves are believed to have been frightened away by the lines. While a vote was pending on a grant to a telegraphic line, a member of the Storthing remarked that, while his constituents had no direct interest in the line, they would support the grant, because the wires would drive away the wolves. It is said that, however hungry a wolf may be, he will never go into a spot that is inclosed by ropes stretched on posts. It is a remarkable fact that since the first telegraphic line was established, twenty years ago, wolves have never appeared in its neighborhood.

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## NOTES.

Professor W. J. Beal, of the Michigan Agricultural College, in a lecture on "The New Botany," gives a description of the old method of teaching that science that reads much like a burlesque—but which we know is too sadly accurate, for persons living have not forgotten how they "studied botany" when they were young—and then sketches the new way in a most attractive style. In the latter, "we study objects before books; a few short talks are given; the pupil is directed and set to thinking, investigating, and experimenting for himself. . . . Before the first lesson each pupil is furnished or told where to procure some specimen for study. . . . For the first recitation each is to tell what he has discovered. The specimens

are not in sight during the recitation. In learning the lesson, books are not used, for, if they are used, no books will contain a quarter of what the pupil may see for himself." And the professor goes on to describe the particular features of his method in a manner that makes most interesting reading.

THE International Committee of the Red Cross (Geneva Convention) has offered prizes for three essays, designed to constitute a series, on "The Art of improvising Means for assisting the Wounded and Sick of Armies." The three essays will relate, respectively, to methods of treatment, means of transportation, and the improvisation of an ambulance or a field-hospital. The consideration of the subjects must be limited to improvisation, and have no reference to fore-prepared means of assistance. The processes suggested should be illustrated by designs when practicable; and the essays should be full, scientific works, not manuals, and should describe expedients that have been tried and tested for practicability. The papers, which may be in English, German, or French, should be sent in before the first day of April, 1883. The awards will be made by an international jury, and will include a prize of five hundred dollars for the best essay on each of the three topics, if worthy, and one hundred dollars to the unsuccessful competitors.

Two views are held regarding the relative age of the copper-bearing traps of Keweenaw Point, Lake Superior, and the Eastern sandstone: one, that the traps and sandstone are of the same age; the other, that the traps are an earlier formation (pre-Palæozoic), and the Eastern sandstone a later one (Palæozoic). Mr. M. E. Wadsworth, having carefully examined the relative position of the two rocks, finds that the Eastern sandstone underlies the trap conformably, "that is, as conformably as a bed can underlie a lava which has flowed over it," and that, therefore, it must be older in order of time, but of the same geological age with the copper-bearing rocks. Hence, the "Keweenawan series," which has been projected upon the theory that the copper-bearing rocks are the older ones, has no foundation. The balance of evidence in regard to the absolute age of the rocks appears to be with the views of Messrs. Whitney and Foster, that they are of the Potsdam age.

SEUBERT having observed that, in the periodic systems of classification of the metals of Meyer and Mendelejeff, platinum comes before gold, while the received atomic weight, 196·7 to 197·8, puts it after that metal, recently undertook the revision of its atomic weight. Having obtained the pure metal, by Schneider's method, he then, with pure potassium chloride and pure ammonium chloride, prepared the double salts by four methods. The mean value of eight experiments, corrected and reduced to a vacuum, gave 194·34050 as the atomic weight of platinum.

THE Peabody Museum of American Archæology and Ethnology has been forced for lack of means to suspend the explorations it had undertaken. Its last report, however, shows that it has done much good work and made many valuable acquisitions. The largest gift received during the year was a collection of Peruvian relics of all kinds, particularly rich in fabrics and garments, received from Dr. W. Sturgis Bigelow, which, added to the other Peruvian collections, makes this department an imposing one. Dr. Flint has brought from Nicaragua many copies of inscriptions on rocks and caves. Mr. Edwin Curtis has procured many thousand specimens, which are recorded in 1,431 entries, from the mounds of Eastern Arkansas. Numerous other hardly less important acquisitions are noticed. The museum has in press a work by Dr. Abbott, of Trenton, New Jersey, on "Primitive Industry, or Illustrations of the Handiwork in Stone, Bone, and Clay, of the Native Races of the Northern Atlantic Seaboard of America."

PROFESSOR DUFOUR has reported to the Helvetic Society of Natural Sciences an interesting observation of what he considers a new proof of the roundness of the earth, in the deformation of images produced on large surfaces of calm water. It may often be witnessed on the Lake of Geneva, and in the case of ships some miles distant at sea.

PROFESSOR M. E. WADSWORTH, of Cambridge, Massachusetts, recently expressed the opinion, founded on his observations in the region, that the amygdaloid cavities and veins in the Keweenaw Point district of Lake Superior had been filled, by the action of water percolating through the rocks, with mineral matter derived from the adjacent rock. Professor J. D. Dana traversed his view, holding that all changes in the rocks took place before the rocks lost their original heat, and were brought about by means of the moisture inclosed at the time of the eruption, acting generally in the vaporized state. Professor Wadsworth has reiterated his views, with a statement of his reasons for adhering to them, before the Boston Society of Natural History. He claims respect for them because they are derived from personal knowledge of the facts, while Professor Dana's views depend on the observations of others. The discussion involves the question of the extent to which water can permeate rocks.

MR. WILLIAM H. JOHNSON, B. Sc., has described before the Manchester Literary and Philosophical Society, a series of experiments in the electrical resistance of iron and steel wire, from which he has drawn the conclusion that the amount of that resistance is a measure of the resistance of the iron or steel to tensile strain, and of the amount of combined carbon, sulphur, silicon, and phosphorus it contains.

THE course of instruction in natural history of the Academy of Natural Sciences, of Philadelphia, which was begun in the spring of 1881, was resumed for the present winter in the first week in January. Courses of from twenty-five to thirty lectures each will be given, with practical demonstrations in the laboratory, on "Physiography and Invertebrate Paleontology," by Professor Angelo Heilprin, and on "Mineralogy," by Professor Henry Carvill Lewis. Professor Heilprin's lectures embrace general considerations relative to various features of the earth's structure and history, and the geological and geographical distribution of past and present life, with special attention in the latter half to practical paleontological demonstrations and advanced instructions. Practical work, including the methods of distinguishing minerals by their external and chemical characters, and blow-pipe analysis, is a regular feature of Professor Lewis's lectures.

MR. FREDERICK CURRY, an English botanist, distinguished chiefly for his studies of the fungi, died September 8th, aged sixty-two years. He had been Secretary, and was at the time of his death Vice-President and Treasurer of the Linnæan Society. His valuable collection of fungi is to be presented to the museum at Kew.

PROFESSOR J. P. WICKERSHAM having been commissioned by the National Educational Association to inquire into the efficiency of education as a preventive of crime, reports that in the prisons of Pennsylvania, the colleges and high-schools are most insignificantly and the fairly educated classes only moderately represented, while one sixth of the crime of the State is committed by the wholly illiterate, who constitute only one thirtieth part of the population. He further concludes that about one third of the crime is committed by persons practically illiterate, and that the proportion of criminals among the illiterate is about ten times as great as among those who have been instructed in the elements of a common-school education or beyond.

M. PASTEUR has succeeded in communicating rabies by inoculation from the brain of a dog dead with the disease. He has also found that by trephining a healthy dog and placing in contact with its brain cerebral tissue from an infected animal, not only is the disease communicated with certainty, but the incubative period is in every case reduced to a few days.

THE Surgeon-General of the United States Army reports that the proportion of cases on the sick list of the army last year was 1,768 per thousand of mean strength among the white troops, and 1,984 per thousand among the colored troops. The average number at one time was 44 per thousand of white, and 45 per thousand of colored troops. About one sixth of the number of white and less than one seventh of the colored sick were cases of wounds, accidents, and injuries. The proportions of deaths to cases treated were 1 to 190 among the whites, and 1 to 97 among the colored troops.

M. FATIO explains the theory of disinfection by sulphurous acid by remarking that the vapors of the acid act in two ways on all organisms that depend on oxygen for life, viz., by asphyxiating them through suppression of that element, and by gradually burning them interiorly, the acid being dissolved in their humors or aqueous parts.

A CATALOGUE of the phenogamous and vascular cryptogamous plants of Indiana, prepared by the editors of the "Botanical Gazette" and Professor C. E. Barnes, names 1,432 species, grouped under 577 genera, and is published, though not absolutely complete, to provoke further additions. The flora of the State is divided into four groups, each marked by the physical aspect of the region in which it is found. The regions may be called the "the river-valleys" "the lake-borders," "the prairies," and "the barrens." The prairie plants are disappearing faster than any others under pressure of cultivation. The splendid forests that originally covered the greater part of the State are rapidly disappearing, and a new race of plants is springing up in their place. New species are continually appearing along the rivers and railroads.

ANOTHER prehistoric canoe has been discovered while digging in the old bed of the Rhône, near the bridge of Gardou, France. It is excavated from an oak-log, which has been left with its natural form, except that the ends have been beveled so as to give a sharp form to the prow and stern. Braces were left in hollowing out the vessel, to extend across the inside and strengthen the sides, and five pairs of holes were bored in the side, for oars. The boat is about thirty-eight feet long, three feet wide, and two feet deep, and would probably hold about twelve men. It was considerably decayed, and was somewhat broken in getting it out, but has been deposited in the museum of Lyons in a tolerably sound condition.

BENJAMIN APTHORP GOULD.